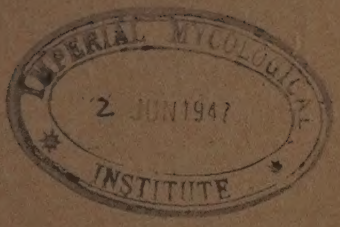
COMPTES RENDUS
(DOKLADY)
DE L'ACADÉMIE DES SCIENCES DE L'URSS

NOUVELLE SÉRIE

1943



VOLUME XXXVIII

№ 7

ÉDITION DE L'ACADÉMIE DES SCIENCES DE L'URSS
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1943

VOLUME XXXVIII, № 7

TABLE DES MATIÈRES

Paseg

MATHÉMATIQUES

M. Bockstein. A Complete System of Fields of Coefficients for the ∇ - Homological Dimension 187

V. Niemytzki. Intégration qualitative du système $\frac{dx}{dt} = Q(x, y)$; $\frac{dy}{dt} = P(x, y)$ en première approximation 190

ASTRONOMIE

V. Hase. Effect of Line Absorption on the Determination of the Temperature of the Inner Corona 193

THÉORIE DE L'ÉLASTICITÉ

E. Steuermann. Some Special Cases of the Contact Problem 197

PHYSIQUE

W. W. Wladimirsky. Possibility of Determining Experimentally the Coefficient of Damping of Elastic Waves of the Debye Spectrum from Observations on the Fine Structure of Lines of Rayleigh Scattering 201

PHYSIQUE MATHÉMATIQUE

G. A. Grünberg. Some Theorems Relating to the Evaluation of Potentials and Charges Induced on Conductors Placed in a Given External Electric Field 203

PHYSIQUE APPLIQUÉE

V. K. Prokofiev. Charcoal Electrodes for Qualitative and Quantitative Spectral Analysis 206

CHIMIE

A. A. Grünberg and **J. L. Mikhelis.** New Method of Preparation of Monohydroxo-Derivatives of Tetravalent Platinum 209
N. A. Vlassov and **A. G. Bergmann.** The Polytherm of the Ternary System: Sodium Chloride—Sodium Bromide—Water from Complete Freezing Point to 50° 211

BIOLOGIE EXPÉRIMENTALE

B. Tokin. The Influence of Phytoncides upon Protozoa 215
A. Kovalenok. Mechanism of Action of Phytoncides upon Protozoa 218

MICROBIOLOGIE

V. L. Rischkov and **A. M. Vovk.** Biological Activity of Acyl Derivatives of the Virus of Tobacco Mosaic 221

HELMINTHOLOGIE

T. S. Skarbilovich. Contribution to the Reconstruction of the Taxonomy of the Trematodes of the Family *Lecithodendriidae* Odhner, 1911 223

Édition de l'Académie des Sciences de l'URSS
Moscou 1943

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1943. Volume XXXVIII, № 7

MATHEMATICS

A COMPLETE SYSTEM OF FIELDS OF COEFFICIENTS FOR THE ▽-HOMOLOGICAL DIMENSION

By M. BOCKSTEIN

(Communicated by A. N. Kolmogoroff, Member of the Academy, 24. VIII. 1942)

▽-homological dimension or simply ▽-dimension of a compactum or a bicompactum A over the field of coefficients $\mathfrak{G}$ ($\mathfrak{G}$ being an additive Abelian group) is the greatest integer q, such that there exists a closed subset $F \subset A$, for which the q-dimensional ▽-homology group $B^q(A-F, \mathfrak{G})$ of $A-F$ over $\mathfrak{G}$ is not trivial (i. e. contains a non-vanishing element).

This new notion of the ▽-homological dimension is connected with the ordinary notion of the homological dimension in the sense of P. Alexandroff([1]) by means of the theory of characters([2]), the ▽-dimension over some field of coefficients being obviously the same as the usual homological dimension over the dual (in the sense of L. Pontrjagin) field of coefficients, for it is easily seen that the ▽-homology groups of a locally bicompact space are defined in such a manner that the groups dual to $B^q(A-F, \mathfrak{G})$ are isomorphic to the relative Betti groups of the bicompactum A, relatively to the bicompactum $F \subset A$.

The notion of the ▽-dimension is not less natural than that of the usual homological dimension. It has even this advantage over the usual concept that here the dimension coinciding with the Urysohn-Brower's dimension is simply the dimension over integer field of coefficients (this theorem can, moreover, in contrast with the dual case, be proved directly, without having recourse to the theory of essential mappings). But the chief advantage of the new notion is the possibility of the application of the methods developed in the precedent note([3]).

The aim of this note is to show that there is no need to know the ▽-dimension of A over all possible fields of coefficients, but that a countable system of coefficient fields can be indicated such that the knowledge of the ▽-dimension of a topological space over the fields of this system permits to calculate its ▽-dimension over arbitrary fields of coefficients.

Using the criterion of the equivalency to zero of a ▽-complex quoted in the precedent note([3]) and observing that the non-triviality of $B^q(A-F, \mathfrak{G})$ means the same as the existence of a q-dimensional ▽-complex of $A-F$ over $\mathfrak{G}$, which is not equivalent to zero, we first prove the following statement.

The q-dimensional ▽-homology group $B^q(A-F, \mathfrak{G})$ of $A-F$ over $\mathfrak{G}$ is certainly not trivial in the following five cases: 1°, if both $\mathfrak{G}$ and $B^q(A-F, \mathfrak{F})$ contain elements of infinite order; 2°, if $\mathfrak{G}$ contains an element of infinite order which is not divisible by the prime p up to elements of finite order, and $B^q(A-F, \mathfrak{F})$ contains an element of order p; 3°, if $\mathfrak{G}$ contains an element of order p, and $B^q(A-F, \mathfrak{F})$ contains an element of infinite order not divisible by p up to elements of finite order; 4°, if both $\mathfrak{G}$ and $B^q(A-F, \mathfrak{F}_p)$

contain elements of finite order which are not divisible by p; 5°, if $\mathfrak{G}$ contains an element of order p, and the ∇-homology group modulo p $B^q(A-F, \mathfrak{J}_p)$ contains an element that is not the «projection» π_p^0 of any element of the integral ∇-group $B^q(A-F, \mathfrak{J})$ ($\mathfrak{J}$ denotes here the additive group of integers, and $\mathfrak{J}_p$ the group of integers reduced modulo p).

Let us prove, for instance, the assertion of the case 1°. Let $\mathfrak{g}$ and u be elements of infinite order respectively in $\mathfrak{G}$ and $B^q(A-F, \mathfrak{J})$. Consider the monomial ∇-complex $\mathfrak{g}u$ and show that it is not equivalent to zero. In fact, suppose it to be equivalent to zero. Then, in virtue of the zero-equivalence criterion, it is possible to represent u as a linear form with integer coefficients

$$u = \sum \beta_\nu b_\nu + \sum \gamma_\nu c_\nu,$$

b_ν being elements of finite order and c_ν those of infinite order, in such a way that for all ν there would be

$$\mathfrak{g}\gamma_\nu = 0.$$

Since u is of infinite order, this implies for all ν $\gamma_\nu = 0$, and hence

$$u = \sum \beta_\nu b_\nu,$$

i. e. u is a linear combination of elements of finite order and is therefore of finite order itself, contrary to the hypothesis.

The proof for the other cases is similar, though more complicated.

Conversely, if the q-dimensional ∇-homology group $B^q(A-F, \mathfrak{G})$ of $A-F$ over $\mathfrak{G}$ is not trivial, one of the cases 1°, 2°, 3°, 4°, 5° necessarily takes place (for at least one prime p).

In order to prove it, we consider separately all possible forms of the q-dimensional ∇-complex not equivalent to zero existing because of the non-triviality of $B^q(A-F, \mathfrak{G})$, which obviously can be supposed monomial, i. e. of the form $\underset{m}{\mathfrak{g}u}$ [$\mathfrak{g} \in \mathfrak{G}$, $u \in B^q(A-F, \mathfrak{J}_m)$, $m\mathfrak{g} = 0$]: 1) $m = 0$, $\mathfrak{g}$ and $\underset{0}{u}$ are elements of finite order; 2) $m = 0$, $\mathfrak{g}$ is an element of finite order, $\underset{0}{u}$ is an element of infinite order; 3) $m = 0$, $\mathfrak{g}$ is an element of infinite order, $\underset{0}{u}$ is an element of finite order; 4) $m = 0$, $\mathfrak{g}$ and $\underset{0}{u}$ are elements of infinite order; 5) $m = p^k \neq 0$.

It can be easily proved that the assumption 1) implies 4°, the assumption 2) implies 4° or 1°, the assumption 3) implies 4° or 2°, the assumption 4) implies 1°, and the assumption 5), if it is not reducible to the just considered ones, implies 5°.

The fundamental result can be formulated as follows:

Theorem. *In order to be able to calculate the ∇-dimension of a topological space A over any field of coefficients $\mathfrak{G}$, it suffices to know it over a countable system γ of fields of coefficients, namely, over the following Abelian groups: a) over the additive group R of rational fractions; b) over the additive groups R_p of rational fractions whose denominators do not contain the prime p as a factor; c) over the cyclic groups C_p of order p (p being a prime); d) over the quasi-cyclic p-groups Q_p, i. e. the groups of rational fractions whose denominators are powers of the prime p.*

Namely, to every field of coefficients $\mathfrak{G}$ ($\mathfrak{G}$ being an additive Abelian group) the following subsystem $\gamma_{\mathfrak{G}}$ of the above system γ of fields of coefficients is correlated.

1) If $\mathfrak{G}$ contains an element of infinite order, then and only then $\gamma_{\mathfrak{G}}$ contains the group R.

2) *If* $\mathfrak{G}$ *contains an element of infinite order which is not divisible by the prime* p *up to the elements of finite order, then and only then* $\gamma_{\mathfrak{G}}$ *contains the group* R_p.

3) *If* $\mathfrak{G}$ *contains an element of finite order not divisible by the prime* p, *then and only then* $\gamma_{\mathfrak{G}}$ *contains the group* C_p.

4) *If* $\mathfrak{G}$ *contains an element of the prime order* p, *then and only then* $\gamma_{\mathfrak{G}}$ *contains the group* Q_p.

Then the ∇*-dimension of* A *over* $\mathfrak{G}$ *is the maximum* (*or, in case of the unboundedness, the supremum*) *of the values of the* ∇*-dimension of* A *over fields of coefficients contained in* $\gamma_{\mathfrak{G}}$.

At the first place we show that the ∇-dimension of A over $\mathfrak{G}$ is not less than that over every field of coefficients contained in $\gamma_{\mathfrak{G}}$. Let, for instance, be $R \in \gamma_{\mathfrak{G}}$. By the definition of $\gamma_{\mathfrak{G}}$ this means that $\mathfrak{G}$ contains an element of infinite order. The ∇-dimension of A over R being denoted by q, there exists a closed subset F of A such that the group $B^q(A-F, R)$ is not trivial. Then, as we have seen, one of the cases 1°, 2°, 3°, 4°, 5° takes place (the rôle of $\mathfrak{G}$ being played by the group R). Since the group R has no elements of finite order and all elements of R are divisible by every p, it is the case 1° that takes place, i. e. $B^q(A-F, \mathfrak{Z})$ has an element of infinite order. As $\mathfrak{G}$ also contains an element of infinite order, the case 1° takes place (now for $\mathfrak{G}$), and consequently the group $B^q(A-F, \mathfrak{G})$ is not trivial, whence follows that the ∇-dimension of A over $\mathfrak{G}$ is $\geqslant q$. The cases $R_p \in \gamma_{\mathfrak{G}}$, $C_p \in \gamma_{\mathfrak{G}}$, $Q_p \in \gamma_{\mathfrak{G}}$ can be considered analogously.

At the second place we prove that, conversely, if the ∇-dimension of A over $\mathfrak{G}$ is equal to q, then the ∇-dimension of A over at least one field of coefficients belonging to $\gamma_{\mathfrak{G}}$ is $\geqslant q$. In fact, there exists then a closed subset $F \subset A$ such that the group $B^q(A-F, \mathfrak{G})$ is not trivial, and thus one of the cases 1°, 2°, 3°, 4°, 5° takes place. If, for instance, we have the case 1°, then $\mathfrak{G}$ contains an element of infinite order, and $R \in \gamma_{\mathfrak{G}}$. Since R also contains an element of infinite order, the case 1° will also take place when the group R is taken instead of $\mathfrak{G}$, so that the group $B^q(A-F, R)$ is not trivial, and the ∇-dimension of A over R is $\geqslant q$. We proceed similarly in the cases 2°, 3°, 4°, 5°.

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Received
24. VIII. 1942.

REFERENCES

[1] P. Alexandroff, Math. Ann., 106, 161—238 (1932). [2] L. Pontrjagin, Topological Groups, ch. V, Princeton (1939). [3] M. Bockstein, C. R. Acad. Sci. URSS, XXXVII, No. 9 (1942).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1943. Volume XXXVIII, № 7

MATHÉMATIQUES

INTÉGRATION QUALITATIVE DU SYSTÈME $\frac{dx}{dt} = Q(x,y)$, $\frac{dy}{dt} = P(x,y)$ EN PREMIÈRE APPROXIMATION

Par V. NIEMYTZKI

(Présenté par A. N. Kolmogoroff, de l'Académie, le 8. X. 1942)

1. Dans une Note récente [1] j'ai indiqué un procédé dénombrable d'intégration qualitative qui conduit à la recherche de toutes les courbes intégrales du système considéré dans un domaine donné. Cependant, quand on analyse d'une manière détaillée la marche de ce procédé, on voit que jusqu'à un certain degré d'exactitude le tableau obtenu est tellement grossier qu'il peut déformer même les traits principaux de la disposition des courbes intégrales; et d'autre part, à partir d'un certain pas on ne peut obtenir que des précisions quantitatives.

Le but du présent travail est d'indiquer ce pas critique et d'éclaircir les singularités de la disposition des courbes, qui peuvent être étudiées au moyen de la construction d'un ε-réseau [1] correspondant à ce pas critique.

2. Soient A et B deux points et $\rho(A, B) = \alpha$ leur distance; menons par les points A et B des cercles de rayon α. Dans l'intersection de ces cercles on obtient un domaine que nous allons nommer figure canonique. Dans la suite nous considérons des domaines canoniques Γ (voir pour les notations la Note précédement citée). Nous nous appuyons ici sur le fait que si les points A et B appartiennent à un domaine canonique et $\rho(A, B) \leqslant \frac{1}{\sqrt{3}} \eta_{\frac{\pi}{12}}(\Gamma)$ [2], alors la figure canonique ne contient pas de points singuliers, ni d'autres points exclus de notre considération.

Définition 1. *Nous dirons qu'un arc intégral* $\overset{\frown}{AB}$ *définit un «sac de Bendixon», si l'on peut trouver sur cet arc un arc partiel* $\overset{\frown}{A_1B_1}$ *tel que:* 1) *le domaine* G, *qui a pour frontières l'arc* $\overset{\frown}{A_1B_1}$ *et le segment* $\overrightarrow{A_1B_1}$, *est simplement connexe;* 2) *chaque courbe intégrale* L *issue d'un point du segment* $\overrightarrow{A_1B_1}$ *doit, quand on la prolonge dans une direction au moins, entrer dans* G *et y rester;* 3) *les points de la frontière de* G *ne sont ni* α*-limites, ni* ω*-limites pour* L [2].

Définition 2. *Nous dirons que deux points* A *et* B *situés sur un certain arc se trouvent dans une gorge de largeur* α, *si* 1) $\rho(A, B) = \alpha$ *et* 2) *le diamètre de l'arc* AB *est supérieur à* α.

Théorème 1. *Si les points* A *et* B *du domaine* Γ *se trouvent dans une gorge de largeur inférieure ou égale à* $\eta_{\frac{\pi}{12}}(\Gamma)$, *alors ou bien l'arc* $\overset{\frown}{AB}$ *définit un sac de Bendixon, ou bien il forme une courbe fermée sans sortir de la figure canonique.*

On déduit de ce théorème deux corollaires. Le premier — c'est le théorème 3 de la Note citée.

Corollaire 1. *Dans un domaine canonique* Γ *il ne peut exister de courbes fermées d'indice inférieur ou égal à* $\frac{1}{\sqrt{3}}\eta_{\frac{\pi}{12}}(\Gamma)$.

Corollaire 2 (généralisation du théorème de Poincaré). *Dans un domaine, borné par une courbe intégrale AB, dont les extrémités se trouvent dans une gorge de largeur inférieure ou égale à* $\eta_{\frac{\pi}{12}}(\Gamma)$, *et par le segment AB, se trouve un point singulier.*

Définition 3. *Une certaine propriété topologique d'un ensemble M sera nommée ε-stable, si cette propriété appartient à une sphère formée de rayon ε décrite autour de M.*

En général, si une propriété subsiste pourvu que $\varepsilon > 0$ soit assez petit, il est naturel de la nommer «grossière».

Théorème 2. *La propriété d'une ε-solution d'indice α de ne pas décomposer le plan en plusieurs domaines est une propriété grossière: elle est* $\frac{1}{3}\alpha$*-stable.*

Théorème 3. *Soit donnée une courbe intégrale L d'indice* $\geqslant \alpha$; *alors la sphère* $S\left(L, \frac{1}{3}\alpha\right)$ *décompose le plan en deux domaines, et deux seulement.*

Pour démontrer cette proposition on s'appuie sur les théorèmes connues de la topologie plane et en premier lieu sur le lemme de Lebesgue (4) ainsi que sur le théorème:

Soient K_1 *et* K_2 *deux compacts. Si* $K_1 + K_2$ *est un H-simplexe, alors le nombre des composantes de* $R - (K_1 + K_2)$ *est égal au nombre des composantes de* $K_1 K_2$. *En s'appuyant sur les théorèmes 1, 2 et 3, on peut décrire ainsi le procédé d'intégration en première approximation.*

Soit donné un domaine canonique $\bar{\Gamma}$; construisons dans ce domaine un $\varepsilon = \frac{1}{8\sqrt{3}}\eta_{\frac{\pi}{12}}(\bar{\Gamma})$-réseau sur la famille des courbes intégrales d'indice $\geqslant \frac{1}{3}\eta_{\frac{\pi}{12}}(\bar{\Gamma})$. Alors on a:

Si le domaine Γ contient des solutions périodiques, il existe un couple de lignes polygonales Λ_1 et Λ_2 du réseau construit, tel que la somme A des sphères de rayons $\leqslant \frac{1}{8\sqrt{3}}\eta_{\frac{\pi}{12}}$, décrites autour de Λ_1 et Λ_2, forme un anneau (parfois il est nécessaire d'ajouter à cette somme certains domaines contenus dans des sphères de rayon $\frac{1}{2\sqrt{3}}\eta_{\frac{\pi}{12}}$, décrites autour des extrémités de Λ_1 et Λ_2).

Les anneaux ainsi construits seront nommés domaines d'indétermination.

Choisissons parmi les lignes polygonales approximatives celles dont les extrémités se trouvent à distance $< \frac{1}{\sqrt{3}}\eta_{\frac{\pi}{12}}$ et sont situées dans une gorge, et joignons leurs extrémités par des segments rectilignes. Décrivons autour de chaque figure plane ainsi obtenue une sphère de rayon $\frac{1}{8\sqrt{3}}\eta_{\frac{\pi}{12}}$. Les domaines obtenus seront nommés sacs de Bendixon approximatifs.

Chaque courbe intégrale d'indice $\leqslant \frac{1}{\sqrt{3}}\eta_{\frac{\pi}{12}}$ *est nécessairement située dans l'un des sacs de Bendixon construits.*

Donc, s'il n'existe pas de sacs de Bendixon, alors toutes les courbes intégrales ont un indice $> \frac{1}{3}\eta_{\frac{\pi}{12}}(\Gamma)$. Ensuite, ou bien un tel arc se trouve indé-

finiment dans l'un des domaines d'indétermination, et alors il s'approche asymptotiquement d'une ligne formée, ou bien il coupe les frontières de plusieurs sacs de Bendixon situés l'un dans l'autre. *A l'intérieur de chaque sac de Bendixon il existe un point singulier.*

3. Considérons maintenant le ε-réseau construit comme un réseau de courbes qui représente la forme des courbes intégrales situées dans le domaine donné.

Introduisons les notions suivantes. Soit $f(x)$ une fonction définie sur un segment $[a\ b]$; nous dirons que $f(x)$ est ε-constante sur $[a\ b]$, si la condition $a \leqslant x_1 < x_2 \leqslant b$ entraîne $|f(x_1) - f(x_2)| \leqslant \varepsilon$. Nous dirons que $f(x)$ est ε-croissante sur $[a\ b]$, si la condition $a \leqslant x_1 < x_2 \leqslant b$ entraîne $f(x_1) \leqslant f(x_2) + \varepsilon$ et $f(x)$ n'est pas ε-constante; on définit d'une manière analogue les fonctions ε-décroissantes. Un point $x = x_0$ est nommé ε-maximum, si l'on peut trouver deux nombres h_1 et h_2, $h_1 < h_2$, tels que 1) la fonction est ε-constante sur le segment $[x_0 - h_1, x_0 + h_1]$, et 2) $f(x)$ n'est pas ε-constante sur le segment $[x_0 - h_2, x_0 + h_2]$; d'ailleurs, pour $(x_0 - h_2, x_0 - h_1)$ et $(x_0 + h_1, x_0 + h_2)$ on a l'inégalité $f(x) < f(x_0)$. On définit d'une manière analogue les ε-minima. Quand on étudie les ε-maxima et ε-minima, il est essentiel de considérer au lieu d'un segment $[x_0 - h_2, x_0 + h_2]$ quelconque celui qui est de longueur maximale, et de considérer l'oscillation de la fonction sur un tel segment. Cette oscillation sera nommée l'amplitude du ε-maximum et ε-minimum correspondant.

Si l'on a une courbe définie par les équations $x = \varphi(t)$, $y = \psi(t)$, alors toutes ces notions peuvent être introduites par rapport à $\varphi(t)$ et $\psi(t)$, c'est-à-dire on peut considérer les x-maxima (minima) et y-maxima (minima). En ce qui concerne les intervalles où la fonction est monotone ou bien constante, il faudra prendre les intervalles où $\varphi(t)$ et $\psi(t)$ sont monotones ou constantes simultanément. En s'appuyant sur ces définitions et les propriétés d'un ε-réseau, on peut énoncer les propositions suivantes.

Comme chaque ligne polygonale Λ_i peut être décomposée en un nombre fini d'intervalles, où les fonctions considérées sont monotones ou constantes, il existe une courbe intégrale L pour laquelle l'écart $\alpha(L, \Lambda_i) \leqslant \eta_\varepsilon(\Gamma)$ et qui se décompose en intervalles, où les fonctions correspondantes sont 3ε-monotones ou 3ε-constantes. Si la ligne Λ_i possède au point A un maximum ou un minimum d'amplitude supérieure ou égale à 2ε, alors la courbe intégrale possède en un point A' à distance $\leqslant \varepsilon$ de A un ε-maximum ou bien un ε-minimum. Inversement, considérons une certaine courbe intégrale d'indice $\geqslant \frac{1}{\sqrt{3}} \eta_{\frac{\varepsilon}{12}}$. On peut toujours la décomposer en un nombre fini d'arcs, où les fonctions correspondantes sont ε-monotones ou ε-constantes; en considérant alors une ligne Λ_i telle que $\alpha(L, \Lambda_i) \leqslant \eta_\varepsilon(\Gamma)$, nous trouvons que sur Λ_i on doit avoir des intervalles, où les fonctions correspondantes sont 3ε-monotones ou bien 3ε-constantes. Si L avait en un certain point un maximum ou un minimum d'amplitude supérieure à 2ε, alors Λ_i possède respectivement un ε-maximum ou bien un ε-minimum en un point à distance inférieure à ε du point considéré sur L.

4. Si l'on effectue une intégration qualitative plus précise, on n'obtient pas de domaines d'indétermination contenant des solutions périodiques et essentiellement nouveaux, c'est-à-dire, non-contenus dans les domaines précédemment considérés. On n'obtiendra pas de nouveaux sacs de Bendixon, mais on précisera seulement l'allure des courbes dans les domaines d'indétermination, on précisera l'allure des courbes intégrales de petits indices et on aura la possibilité de juger plus précisement quels sont les maxima, les minima et les intervalles, où les fonctions sont monotones ou constantes pour les courbes intégrales situées dans $\bar{\Gamma}$.

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Manuscrit reçu
le 20. VIII. 1942.

LITTÉRATURE CITÉE

[1] V. Niemytzki, C. R. Acad. Sci. URSS, XXXVIII, No. 2—3 (1943). [2] Биркгоф, Динамические системы, гл. VII (1941).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1943. Volume XXXVIII, № 7

ASTRONOMY

EFFECT OF LINE ABSORPTION ON THE DETERMINATION OF THE TEMPERATURE OF THE INNER CORONA

By V. HASE

(Communicated by G. Shajn, Member of the Academy, 27. X. 1942)

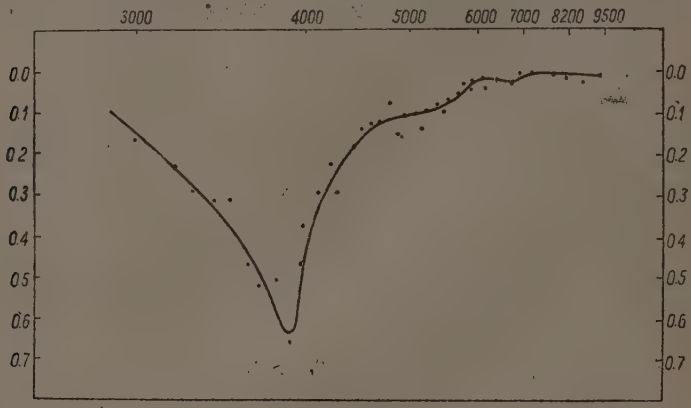
Schwarzschild's hypothesis of the electronic nature of the inner corona has two important consequences which may be directly tested by observation.

In the proximity of the sun the thermal velocities of the free electrons must average about 350—450 km/sec.; this speed will broaden the Fraunhofer lines to such an extent, that they will nearly or completely disappear. Really, Fraunhofer lines are not observed in the spectrum of the inner corona, and this fact is usually regarded as favourable for Schwarzschild's hypothesis. But this holds only for the usual narrow Fraunhofer lines, which in the solar spectrum have a width of some tenths of an Ångström, or less, while for strong and broad lines, such as *H* and *K*, the state of things must be different. G. Shajn[1] and D. Menzel[2] found independently from the 1936 eclipse that within 2′—4′ from the sun's limb the spectrum of the inner corona is devoid of any traces of the *H* and *K* lines. G. Shajn has shown by detailed computations, that the *H* and *K* lines in the spectrum of the inner corona must be comparable in depth to the hydrogen lines in *A*-type stars. Thus, strictly speaking, the above argument turns against the hypothesis, and not in its favour; or one must look for such an alteration of the hypothesis, which would imply not thermal velocities, but average speeds of the order of some thousands of km/sec. Another consequence rests upon the fact that electron scattering, as being independent of wave-length, must produce an energy distribution within the continuous spectrum of the corona similar to that of the sun. As, apparently, at least for the inner corona, there is observed an energy distribution close to that of the sun, this result is usually interpreted as a second argument in favour of Schwarzschild's hypothesis. Neither here can one say, however, that everything was right.

Usually the coronal spectrum is compared with the solar one, the latter serving as a standard, and the effect of the Fraunhofer lines on the result of this comparison is let out of consideration. Meanwhile it is known from stellar spectrophotometry that the influence of the absorption lines on temperature determinations cannot always be neglected, especially in the violet and ultraviolet part of the spectrum[3]. The presence of a great number of crowded absorption lines produces at low and moderate dispersion, when they are blended, a notable lowering of the continuous spectrum, which depends on the number and intensity of the lines and will be especially strong in the violet region. Were this effect equal for the sun and the corona, it could be neglected in the relative determination of the temperature. But this effect is rather different and dependent on various conditions. Our aim is to show, that in some cases the problem of determining the colour temperature of the corona gives no single-valued solution.

The problem of the amount of absorption by lines in the solar spectrum was studied in detail by Mulders. Using Rowlands estimates of intensity of all lines and photometric measurements of typical lines, Mulders computed the total absorption by lines for intervals of 100 Å. He gives in table II of his paper the values I_T characterizing the line absorption in per cent of intensity of the continuous

spectrum. If we denote by $I_\lambda = 1 - I_T$ the averaged intensity for the mean wavelength of the given interval, affected by line absorption, and by I_0 the intensity of the continuous spectrum averaged over the same interval of λ and taken as unity, the function $F(m) = \frac{5}{2} \lg \frac{I_0}{I_\lambda}$ will characterize the energy distribution in the solar spectrum, when the dispersion is so low, that separate Fraunhofer lines become invisible. This function, expressed in stellar magnitudes and represented in the figure, served as basis for the discussion. We assume, according to Schwarzschild's hypothesis, that the absorption lines in the coronal spectrum are completely obliterated in view of the high velocities of scattering electrons. Consequently, the continuous spectrum of the corona will be distorted independently of



Distribution of total line absorption along the solar spectrum (each dot within λ 3000—6200 relates to an interval of 100 Å).

the dispersion used, and the account of the lines in drawing the background will be impossible. Curve *1* will characterize the energy distribution in the coronal spectrum at every dispersion. As concerns the solar spectrum serving as comparison standard, the exactitude of drawing the background will depend on the dispersion, and, consequently, the value of the colour temperature of the corona will be different for different instrumental conditions. Let us consider cases of different dispersion.

1. High Dispersion. The absorption lines in the solar spectrum, with the exception of the faintest, perhaps, are visible and the continuous spectrum can therefore be drawn correctly, while that of the corona will be lowered, according to the figure. We shall consider the line effect for three limited spectral regions. In the photographic region (λ 3900—5000) the continuous spectrum of the corona will be lowered as compared with the correct background in the solar spectrum, and, consequently, the colour temperature of the corona, found in this way, will be lower, than the solar temperature; the same will hold for the visual part of the spectrum, but here the difference in temperature will be less, owing to the smaller number of strong absorption lines (λ 5000—6700). In the ultra-violet, on the contrary (λ 3200—3900), the comparatively smaller lowering for shorter wavelengths will make the illusion of higher temperature of the corona. When determining in the usual way the temperature gradients for these three spectral regions referred to the sun as a standard of 6000°, we shall find following values for the colour temperature of the corona:

λ	T
3200—3900	8200°
3900—5000	4550
5000—6700	5600

i. e. the colour temperature of the corona, determined from limited parts of the spectrum, will be different in view of the different distribution in number and intensity of the absorption lines in the solar spectrum.

2. Low Dispersion. In the limiting case, when the dispersion of the spectrograph is so low, that no lines at all are seen in the solar spectrum, the continuous spectra of both the sun and the corona will be lowered equally, although the cause of this depression will be different. In the coronal spectrum this depression is a matter of principle, and independent of dispersion, while in the solar spectrum instrumental conditions are responsible for the lowering of the background. As the energy distribution will be similar on both spectrograms, the colour temperature of the corona will be estimated as 6000°. This result will be correct, if the effective temperatures of the sun and corona are equal; if not, it will still be correct in first approximation.

3. In the case of moderate dispersion, when the strongest lines are seen, the effect in question is only partly manifested and the continuous spectrum is lowered less. To estimate the effect of line absorption, we shall conventionally reduce by half the values given by Mulders and compute an analogous curve. Both spectra will be lowered, but while in the coronal spectrum the effect of line absorption enters in its full extent, in the solar one this effect is reduced; consequently, the violet region in the coronal spectrum will be more depressed than in the solar one. An analogous computation will yield for the colour temperature of the corona:

λ	T
8200—3900	7000°
3900—5000	5200
5000—6700	5850

This case is probably the closest to those occurring in practice.

Thus, if starting from Schwarzschild's hypothesis, we assume that the absorption lines in the coronal spectrum are obliterated in consequence of high electronic speeds; the temperature of the inner corona, determined without allowance for the absorption lines, proves to be somewhat different for different spectral regions. This fact appears inconsistent with the conception of coronal light as scattered solar light or the adopted notion of the observed equal energy distribution within the coronal and solar spectra.

Even if it is possible with the help of certain additional research to make allowance for lowering of the background in the solar spectrum for the given dispersion, yet one will have thereby all the cases considered reduced to the first one, where the background in the solar spectrum is drawn correctly, while in the coronal spectrum its actual position remains unknown and, consequently, the temperature indeterminable.

The determination of the temperature of the inner corona from photographic observations with different colour filters is, at first sight, free from the complication due to the line absorption, inasmuch as the images of the sun and corona will be equally affected by this cause. But this will be true only on the condition that the energy absorbed by the given lines is re-emitted within the considered part of the spectrum. Probably, this condition is justified. There remains to mention the possible effect of the emission lines in the coronal spectrum on temperature determination; the latter must be quite insensible, because the intensity of emission lines, as averaged over the spectral regions considered, is small: according to the photometric measurements by G. Shajn for the 1936 eclipse, it turns out to be 2% for the visual and only 0.3% for the photographic part of the spectrum.

It is considered, as established from the observations by Ludendorff [4] and Grotrian [5] of the 1923 and 1929 eclipses, respectively, that the intensity distribution in the continuous spectra of the corona and sun coincides within the limits of $\pm 0^m.1$, i. e. the accuracy of observations. But still, this result cannot be regarded as a confirmation of Shwarzschild's hypothesis. Really, the equality of gradients of the sun and corona gives no single-valued solution; it will be different for different spectral regions and will vary with instrumental conditions.

We give in the following scheme the possible interpretation of the equality of gradients of the sun and corona from two standpoints as to the absence of the absorption lines: 1) Schwarzschild's hypothesis of the obliteration of lines and 2) the supposition that the nature of the coronal light is such that it produces a purely continuous spectrum with emission lines, but devoid of absorption lines, owing to some physical cause.

Spectral region	Schwarzschild's hypothesis	Purely continuous spectra
	High dispersion	
Ultra-violet	T_e cor. lower than T_e ⊙	T_e cor.$=T_e$ ⊙
Photographic	T_e cor. higher than T_r ⊙	T_e cor.$=T_c$ ⊙
Visual	T_e cor. slightly higher than T_r ⊙	T_r cor.$=T_c$ ⊙
	Low dispersion	
Ultra-violet	T_e cor.$=T_e$ ⊙	T_e cor. higher than T_e ⊙
Photographic	T_e cor.$=T_r$ ⊙	T_e cor. lower than T_e ⊙
Visual	T_e cor.$=T_e$ ⊙	T_e cor. slightly lower than T_e ⊙

The intermediate case of moderate dispersion yields, on the assumption of Schwarzschild's hypothesis, a solution qualitatively similar to the case of high dispersion, and, on the assumption of total absence of absorption lines, a solution qualitatively similar to the case of low dispersion.

Let us put the reverse question: what must show the spectrophotometric observations, if Schwarzschild's hypothesis is true? The equality of effective temperatures requires that on spectrograms taken with high dispersion the observed gradient of the corona should be less in the ultra-violet, greater in the photographic, and slightly greater in the visual part as compared to the sun's gradient. At low dispersion the gradients must be equal.

Consequently, the confirmation of Schwarzschild's hypothesis is to be sought for not in the full coincidence of energy distribution within the coronal and solar spectra, but in the slight systematic deviations between them, which may be perhaps interpreted as a result of line absorption effect. On Grotrian's diagram, showing the comparison of both spectra, the ultra-violet and photographic parts of the coronal spectrum are lowered just in the sense required by line absorption, the difference reaching its maximum at approximately 4000; the quantitative evaluation of this difference is not possible as it is at the limit of the accuracy of observations, but qualitatively the character is right. The visual part of the coronal spectrum is also lowered, but too much to be ascribed to line absorption; possibly, the depression here may be explained by photographic properties of the plates.

However, at the present state of things one must recognize, that Shwarzschild's hypothesis of the electronic nature of the inner corona is in partial contradiction just with those observational data which are usually brought forward for its justification, since the thermal speeds of free electrons must, on the one hand, distort the energy distribution within the continuous spectrum, and are, on the other hand, insufficient to explain the absence of the absorption lines *H* and *K*.

I wish to express my gratitude to Prof. G. A. Shajn who has suggested the problem and allowed me the use of his results of the observation of the 1936 eclipse before publication.

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Received
23. XI. 1942.

REFERENCES

[1] G. Shajn, C. R. Acad. Sci. URSS, XXVIII, No. 9 (1940). [2] D. Menzel, Transactions of the International Astronomical Union, VI, 437 (1938). [3] G. Shajn, Monthly Notices of the R. A. S., 94, 642 (1934). [4] H. Ludendorff, Sitzungsber. d. Preuss. Akad. d. Wiss., 5, 83 (1925). [5] W. Grotrian, ZS. f. Astrophys., 3, 199 (1931).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1943. Volume XXXVIII, № 7

THEORY OF ELASTICITY

SOME SPECIAL CASES OF THE CONTACT PROBLEM

By E. STEUERMANN

(Communicated by S. L. Soboleff, Member of the Academy, 3. IX. 1942)

The solution of the contact problem, as suggested by Hertz, is based on the assumption that when there are two bodies in contact, the distance $l(x, y)$ between their two points measured along their common normal to the tangent plane is approximated by means of a quadratic form of second degree. One special case of the contact problem — when the second derivatives of the function $l(x, y)$ vanish at the origin — has already been examined by me in an earlier paper (1).

In this one I am dealing with another special case of elastic bodies pressed together. Namely, that in which their original point of contact (the origin) is a singular point for the second derivatives of the function $l(x, y)$. As before, we restrict the discussion to cases of axial symmetry and of the plane contact problem. When there is axial symmetry, the pressure p upon the surface of pressure and the radius of the latter ρ are defined by the integral equation

$$(\vartheta_1 + \vartheta_2) \int_0^{2\pi} \int_0^{\rho} p(r') \left(\frac{1}{r'} - \frac{1}{\sqrt{r^2 - 2rr' \cos\varphi + r'^2}} \right) r' dr' d\varphi = l(r) \quad (r \leqslant \rho) \qquad (1)$$

and by the condition

$$2\pi \int_0^{\rho} p(r') r' dr' = P, \qquad (2)$$

where $\vartheta_1 = \frac{1 - \sigma_1^2}{\pi E_1}$, $\vartheta_2 = \frac{1 - \sigma_2^2}{\pi E_2}$, $E_1, \sigma_1, E_2, \sigma_2$ are elastic constants of the bodies under reciprocal pressure, P is the force of pressure. In the plane problem, giving up the assumption that function l is an even function, the pressure p and the dimensions of the surface of pressure are defined by the integral equation

$$2(\vartheta_1 + \vartheta_2) \int_{-a}^{b} p(x') \ln \left| \frac{x - x'}{x'} \right| dx' = l(x) \quad (-a \leqslant x \leqslant b) \qquad (3)$$

and the condition

$$\int_{-a}^{b} p(x')\, dx' = P. \qquad (4)$$

We start by considering the case when the second derivative of function $l(x)$ has a break in continuity at the origin. No such case is possible if

there is axial symmetry; so we confine ourselves to the examination of the plane problem. Introduce the notation

$$\left(\frac{d^2l}{dx^2}\right)_{x=+0}=2A_+,\ \left(\frac{d^2l}{dx^2}\right)_{x=-0}=2A_-. \tag{5}$$

In a small interval $0<x\leqslant b$ the function l will be approximated by the expression A_+x^2, and in another small interval $-a\leqslant x<0$ it will be approximated by the expression A_-x^2. Substituting the variables in eq. (3)

$$x=\frac{1}{2}(b-a)+\frac{1}{2}(b+a)\,t,\quad x'=\frac{1}{2}(b-a)+\frac{1}{2}(b+a)\,\tau,$$

we bring this equation to the form

$$(\vartheta_1+\vartheta_2)(a+b)\int_{-1}^{1}p\ln\left|\frac{t-\tau}{t_0-\tau}\right|d\tau=l\left[\frac{1}{2}(b-a)+\frac{1}{2}(b+a)\,t\right], \tag{6}$$

where

$$t_0=\frac{a-b}{a+b}.$$

If the first derivative of function l is continuous in the interval $(-a, b)$ and equation (6) has a bounded solution, then this solution is obtained from the formula

$$p=\frac{\sqrt{1-t^2}}{2\pi^2(\vartheta_1+\vartheta_2)}\int_{-1}^{1}\frac{l'\left[\frac{1}{2}(b-a)+\frac{1}{2}(b+a)\,\tau\right]d\tau}{(\tau-t)\sqrt{1-\tau^2}}. \tag{7}$$

Computations in this case, putting $t=\cos\varphi$ and $t_0=\cos\varphi_0$, give

$$p=\frac{a+b}{2\pi^2(\vartheta_1+\vartheta_2)}\left\{\sin\varphi\,[A_+\varphi_0+A_-(\pi-\varphi_0)]+\right.$$
$$\left.+(A_+-A_-)(\cos\varphi-\cos\varphi_0)\ln\left|\frac{\sin\frac{\varphi+\varphi_0}{2}}{\sin\frac{\varphi-\varphi_0}{2}}\right|\right\}. \tag{8}$$

The expression found presents the solution of equation (6) if and only if

$$\int_{-a}^{b}\frac{p(x')\,dx'}{x'}=0. \tag{9}$$

This condition leads to the following equation by which the angle φ_0 is defined:

$$\operatorname{tg}\varphi_0-\varphi_0=\frac{\pi}{\frac{A_+}{A_-}-1}. \tag{9a}$$

Substituting (8) into (4), we find the breadth of the surface of pressure $a+b$:

$$a+b=\frac{2}{\sin\varphi_0}\sqrt[3]{\frac{2\pi P(\vartheta_1+\vartheta_2)}{(A_+-A_-)\operatorname{tg}\varphi_0}}. \tag{10}$$

The pressure we have found may be reduced to force P and moment

$$M=\int_{-a}^{b}p(x')\,x'dx'=\frac{1}{3}(b-a)\,P. \tag{11}$$

Thus, in our case the necessary condition for the bodies under mutual pressure to be in equilibrium is that the resultant of the compression forces be displaced with respect to the original point of contact of the bodies and cross the abscissae axis at point $x=\frac{b-a}{3}$. In Fig. 1 the distribution of pressure over the pressure surface is shown for $\varphi_0=120°$. The obtained solution is based on the usual assumption that in the case of compression the relative displacement of the bodies is a forward movement. Under these conditions the tie which checks the relative turning of the pressed bodies takes upon itself the moment M as defined by formula (11). If, on the other hand, the bodies under pressure are free to turn relative to each other, then pressure p, the dimensions of the pressure surface and the angle of relative rotation ω are defined by the integral equation

$$2(\vartheta_1+\vartheta_2)\int_{-a}^{b} p(x')\ln\left|\frac{x-x'}{x'}\right|dx' = l(x)-\omega x \qquad (-a\leqslant x\leqslant b) \qquad (12)$$

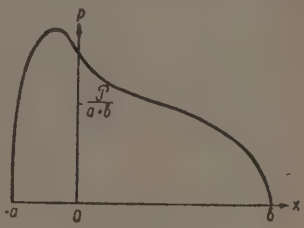


Fig. 1.

and by the conditions

$$\int_{-a}^{b} p(x')\,dx' = P, \quad \int_{-a}^{b} p(x')\,x'dx' = 0 \qquad (13)$$

(the angle ω is said to be positive, if the drawing nearer together on rotation is from the side of the positive half-axis x). In the case considered, pressure p is again defined by formula (8). The second of the conditions (13) leads to the following equation for angle φ_0:

$$\operatorname{tg}\varphi_0+\sin 2\varphi_0-3\varphi_0=\frac{3\pi}{\frac{A_+}{A_-}-1}. \qquad (14)$$

Making use of the first condition of (13), we find the breadth of the pressure surface

$$a+b=\frac{2}{\sin\varphi_0}\sqrt{\frac{3\pi P(\vartheta_1+\vartheta_2)}{(A_+-A_-)\operatorname{tg}\varphi_0}}. \qquad (15)$$

Differentiating (12) with respect to x and setting $x=0$, we find ω:

$$\omega=2(\vartheta_1+\vartheta_2)\int_{-a}^{b}\frac{p(x')\,dx'}{x'}=\frac{16P(\vartheta_1+\vartheta_2)}{a+b}\cos\varphi_0. \qquad (16)$$

Let us now turn to the case when the second derivative of the function l becomes infinite at the origin. In the general case the solution, though reducible to quadratures, requires very cumbersome calculations. We have dwelt in detail on the case when function l can be approximated within the surface of pressure by the expression $Ar^{\frac{3}{2}}$ in the case of axial symmetry; by the expression $A|x|^{\frac{3}{2}}$ in the plane problem. These problems are solved in elliptical integrals. First, we will examine the case of axial symmetry. The solution of equation (1) can be represented in the form

$$p(r)=\frac{1}{\pi^2(\vartheta_1+\vartheta_2)}\int_0^{\frac{\pi}{2}}d\alpha\int_0^{\sqrt{\rho^2-r^2}\sin\alpha}\Delta l\left(\sqrt{r^2\sin^2\alpha+y^2}\right)dy, \qquad (17)$$

where

$$\Delta l(r) = \frac{1}{r}\frac{dl(r)}{dr} + \frac{d^2 l(r)}{dr^2}.$$

Putting in (17)

$$l(r) = Ar^{\frac{3}{2}}$$

and performing the computations, we find

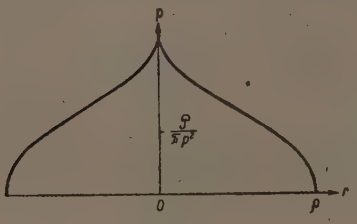
$$p = 2.5\frac{P}{\pi\rho^2}\left\{\sin\varphi\sqrt{1+\cos^2\varphi} + \frac{\sqrt{2}}{2}\cos\varphi\,[F(\varphi) - 2E(\varphi)]\right\}, \qquad (18)$$

where

$$\cos\varphi = \sqrt{\frac{r}{\rho}},\quad F(\varphi) = \int_0^{\varphi}\frac{d\varphi}{\sqrt[3]{1-\frac{1}{2}\sin^2\varphi}},\quad E(\varphi) = \int_0^{\varphi}\sqrt[3]{1-\frac{1}{2}\sin^2\varphi}\,d\varphi.$$

Substituti on of (18) in (2) gives the radius of the pressure surface ρ:

$$\rho = \left[\frac{10\sqrt{2}\pi(\vartheta_1+\vartheta_2)P}{9A(2E-K)}\right]^{\frac{2}{5}}. \qquad (19)$$



Flg. 2.

In Fig. 2 the distribution of pressure over the pressure surface is shown for the case examined. In the plane problem, if $l = A|x|^{\frac{3}{2}}$

$$p = 1.5\frac{P}{\pi a}\left\{\sin\varphi\sqrt{1+\cos^2\varphi} + \right.$$
$$\left. + \frac{\sqrt{2}}{2}\cos\varphi\,[F(\varphi) - 2E(\varphi)]\right\} \qquad (20)$$

where

$$\cos\varphi = \sqrt{\frac{|x|}{a}},$$

The half-breadth of the pressure surface is defined by the equation

$$a = \left[\frac{\sqrt{2}\pi(\vartheta_1+\vartheta_2)P}{2AK}\right]^{\frac{2}{3}}.$$

As is seen from formulae (18) and (20), the distribution of pressure over the surface of pressure has the same character in the case of axial symmetry, as in the plane problem.

Received
3. IX. 1942.

REFERENCES

[1] E. Steuermann, C. R. Acad. Sci. URSS, XXV, No. 5 (1939); XXIX, No. 3 (1940); XXXI, No. 8 (1941).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1943. Volume XXXVIII, № 7

PHYSICS

POSSIBILITY OF DETERMINING EXPERIMENTALLY THE COEFFICIENT OF DAMPING OF ELASTIC WAVES OF THE DEBYE SPECTRUM FROM OBSERVATIONS ON THE FINE STRUCTURE OF LINES OF RAYLEIGH SCATTERING

By W. W. WLADIMIRSKY

(Communicated by L. I. Mandelstam, Member of the Academy, 25. VIII. 1942)

The intensity of the Rayleigh part of scattered light in a crystal is proportional to the intensity of Debye oscillations. In a not uniformly heated body the intensity of low frequency Debye oscillations will not strictly reproduce the curve of temperature variations. In 1934 Mandelstam[1] reported on an anomaly in the intensity of scattered light, connected with this phenomenon. The distribution of intensity over the volume of a body will the more deviate from its temperature distribution, the lower the damping $\frac{1}{l}$ of those acoustic waves which are essential for the scattering of light of a given frequency (l is the free path). By the temperature in a given point of the crystal we understand here a temperature corresponding to the intensity of short-wave (limit) oscillations. A theoretical investigation of this anomaly[2] has shown that the effect can be recorded only at a distance l from the edge of the body, in case the temperature gradient remains constant all over its volume. In the middle parts of a crystal the intensity of the scattered light shows a normal value, proportional to the temperature at a given point. This has been studied experimentally by Landsberg and Choubine [3] for a quartz crystal. Within experimental accuracy the distribution of intensity has not been found to deviate from the normal one. Hence the following evaluation of the coefficient of absorption of elastic waves with a frequency of the order of 2×10^{10} sec.$^{-1}$

$$\frac{1}{l} > 0.75 \text{ cm}^{-1}. \qquad (1)$$

The possibility of observing the fine structure of the Rayleigh line in quartz points, however, to the fact that the free path of the Debye waves, responsible for light scattering, should considerably exceed the length of these waves. We are thus led to the value

$$\frac{1}{l} < 10^4 \text{ cm}^{-1}. \qquad (2)$$

Theoretical investigation of sound damping in dielectrics [4,5] has shown, that the order of magnitude of the absorption coefficient can be evaluated from only that part of damping which is due to heat conductivity. This leads us to values of $\frac{1}{l}$ of the order of several cm^{-1} (for quartz), which does not contradict the experimental data (1, 2).

If the crystal has a temperature gradient, the intensity distribution of Debye oscillations varies according to the direction. The intensity of those waves which

propagate in the direction of the heat flow is higher than of those, propagating in the opposite direction. From the calculations made by Leontovitsch [2] it is no difficult matter to obtain the difference ratio between the intensities I^+ and I^- of the waves, propagating in the directions $\mathbf{q}$ and $-\mathbf{q}$ ($\mathbf{q}$ is unit vector), and the medium intensity I, at a point remote from the edges of the crystal*:

$$\frac{I^+ - I^-}{I} = \frac{l\mathbf{q}\nabla T}{T} . \qquad (3)$$

The intensities of these waves can be measured separately, if the fine structure of the Rayleigh scattering line is investigated. In fact, let $\mathbf{q}$ be directed along the difference of the wave-vectors of scattered and incident light $\mathbf{q} = (\mathbf{k} - \mathbf{k}_0)/|\mathbf{k} - \mathbf{k}_0|$. In this case the light scattered for a wave, propagating along $\mathbf{q}$, will show a frequency greater by $V|\mathbf{k} - \mathbf{k}_0|$ than the incident light: it forms the so-called violet satellite of the Rayleigh line (V is sound velocity). A wave, propagating along $-\mathbf{q}$, will yield a red satellite situated symmetrically. The intensity of the violet satellite is proportional to I^+, the intensity of the red one, to I^-. Thus, *if in a not uniformly heated body the drop of temperature all along the free path of Debye waves, essential for scattering of light, makes up an appreciable figure, then the intensities of the red and the violet satellite will differ from each other.* It is of interest to note that the inequality of the intensities of the red and the violet satellites is no boundary effect: on the contrary, in a layer of thickness l near the boundary of the crystal $I^+ - I^-$ must be somewhat lower than in the middle of the crystal, owing to the reflection of the elastic waves from the boundary. An essential advantage of the present method is the possibility to carry on the observations far from the edges of the crystal. A second no less important advantage is the possibility to observe separately acoustical waves of different polarization, since the absence of losses by heat conductivity for transverse waves gives us ground to suppose that their free path is somewhat longer than that of longitudinal waves. The intensity of separate components of the fine structure cannot be measured with such an accuracy as the total intensity. The anticipated differences between the intensities $I^+ - I^-$ are, however, considerably greater than the anomalies in the distribution of the mean intensity I. One may therefore expect that the investigation of the fine structure in a not uniformly heated body will prove a more sensitive method than the investigation of the boundary anomalies of the total intensity. It seems probable that if work is carried on in this direction, one may not only succeed in estimating the lower value of the coefficient of damping, but even in measuring this quantity.

The quantum effects in the case of the light scattering may lead to a certatin preponderance of the intensity of the red satellites over that of the violet ones. The difference, however, which is connected with the quantum degeneracy of Debye's phonons with a frequency of the order of 2×10^{10} sec.$^{-1}$ at room temperature must be quite negligible, for the relation $\frac{h\nu}{kT}$ does not under these conditions exceed 4×10^{-3}. Besides, the quantum effect does not depend upon the direction of the heat flow and can easily be eliminated experimentally.

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Received
24. VI. 1942.

REFERENCES

[1] L. I. Mandelstam, C. R. Acad. Sci. URSS, II, 219 (1934). [2] M. Leontovitsch, Journ. of Phys., 1, 397 (1939). [3] Landsberg et A. Choubine, ibid., 1, 403 (1939). [4] A. Akhieser, ibid., 1, 277 (1939). [5] И. Я. Померанчук, ЖЭТФ, 11, 455 (1941).

* In our notation $\frac{1}{l}$ is the coefficient of damping of the sound range. In Leontovitsch's formulae $a = \frac{2}{l}$ is the coefficient of damping of the intensity([2]). Formula (3) is obtained from (11) and (12) of the cited paper by Leontovitsch, if the distances of the point examined from the edges of the crystal be put at infinity.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1943. Volume XXXVIII, № 7

MATHEMATICAL PHYSICS

SOME THEOREMS RELATING TO THE EVALUATION OF POTENTIALS AND CHARGES INDUCED ON CONDUCTORS PLACED IN A GIVEN EXTERNAL ELECTRIC FIELD

By G. A. GRÜNBERG

(Communicated by A. F. Joffe, Member of the Academy, 14. IX. 1942)

The following propositions may be of use in calculating potentials, to which conductors are raised when placed in an external electric field.

Theorem 1. *The potential V, to which an insulated conductor is raised when placed in an external electric field, may be found by a single quadrature, if the distribution σ^0 of the surface density on this conductor is known in the absence of an external field.*

Let φ_e denote the potential of the given external field and let φ^0 be the potential of the field which corresponds to the «free» surface distribution σ^0. Let A and B be two points on the surface (f) of the given conductor, and let $\sigma = \sigma(A)$ denote the actual density at A in the presence of the external field. Then the equation holds

$$\int_{(f)} \frac{\sigma(A)\,df_A}{r_{AB}} + \varphi_e = V = \text{const}, \tag{1}$$

where df_A denotes a surface element in the vicinity of A, and r_{AB} is the distance between A and B.

Multiplying (1) by $\sigma^0(B)\,df_B$, integrating over the surface $f_B = f$ of the conductor and reversing the order of integration in the repeated integral, we get

$$\int_{(f)} \sigma^0(B)\,df_B \int_{(f)} \frac{\sigma(A)\,df_A}{r_{AB}} = \int_{(f)} \sigma(A)\,df_A \int_{(f)} \frac{\sigma^0(B)\,df_B}{r_{AB}} = \int_{(f)} \varphi^0(A)\,\sigma(A)\,df_A = \varphi^0 e,$$

where $\varphi^0(A) \equiv \varphi^0$ is the constant potential of the conductor, due to the surface distribution σ^0, and $e = \int_{(f)} \sigma(A)\,df_A$ denotes the total charge on the conductor in the presence of the external field. Choosing σ^0 in such a way that $\varphi^0 = 1$, we thus get

$$e + \int_{(f)} \varphi_e \sigma^0(B)\,df_B = V \int_{(f)} \sigma^0(B)\,df_B = VC^0,$$

where $C^0 = \int_{(f)} \sigma^0(B)\,df_B$ denotes the capacity of the given conductor in the

absence of other conductors. Dropping the unnecessary subscript (B), the last equation gives

$$V = \frac{e + \int_{(f)} \sigma^0 \varphi_e df}{C^0} \tag{2}$$

which is the result required.

Corollary 1. If the conductor is uncharged, equation (2) simplifies to

$$V = \frac{\int_{(f)} \sigma^0 \varphi_e df}{C^0}. \tag{3}$$

Corollary 2. If the conductor is put to earth, i. e. when $V = 0$, we find for the charge e induced on it

$$e = -\int_{(f)} \sigma^0 \varphi_e df. \tag{4}$$

Example 1. Let us consider a spherical conductor of radius R. Then $\sigma^0 = C^0/4\pi R^2$, and (3) gives

$$V = \frac{1}{4\pi R^2} \int_{(f)} \varphi_e df = \bar{\varphi}_e, \tag{5}$$

where $\bar{\varphi}_e$ denotes the mean value of the potential of the given external field over the surface of the given conducfor.

Example 2. Let the conductor (f) be a long straight thin wire, which we shall treat as a prolate ellipsoid with an eccentricity approaching unity and a major axis equal to the half-length of the wire. Such an ellipsoid, when freely electrified, possesses such a distribution of surface density σ^0 which, as regards its field outside ellipsoid, is equivalent to a uniform linear distribution of electricity over the straight line joining the foci of the ellipsoid. Eq. (3) gives therefore approximately

$$V = \frac{1}{C^0} \int_{(f)} \sigma^0 \varphi_e df \cong \frac{1}{C^0} q^0 \int_{(s)} \varphi_e ds, \tag{6}$$

where the last integration extends over the focal distance and where $q^0 \cong C^0/2l$ denotes the charge per unit length of this distance (it is assumed that the potential of the external field varies but little over the cross-section of the wire).

Example 3. The external field is due to unit point charge at a certain point P. Then $\varphi_e = \frac{1}{r}$, where r is the distance from P, and (3) gives

$$V = \frac{1}{C^0} \int_{(f)} \frac{\sigma^0 df}{r}. \tag{7}$$

This equation simply expresses the well known proposition that the potential, to which the conductor is raised by placing unit charge at P, the conductor itself being uncharged, is equal to the potential at P when unit charge is placed on the conductor.

Theorem 2. *If a system consisting of n conductors is under the influence of a given external field, then the potential, to which one of the conductors constituting the system is raised by the presence of this field, may be found by quadratures, if the density distribution on the conductors of the system is known, which corresponds to the condition that the conductor under consideration has unit charge and all the other conductors of the system are uncharged, no external field being present* (this is obviously a generalization of Theorem 1).

To prove this proposition, we use Green's reciprocation theorem which, in a form suitable for our purpose, may be stated as follows:

Let two different surface distributions σ and σ' of charges on the surfaces (f_i) of the conductors, constituting our system, produce respectively potentials φ and φ' in the points of the surfaces of these conductors. Then evidently

$$\sum_{i=1}^{i=n} \int_{(f_i)} \sigma_i \varphi_i' df_i = \sum_{k=1}^{k=n} \int_{(f_k)} \sigma_k' \varphi_k df_k = \left(\sum_{i=1}^{i=n} \sum_{k=1}^{k=n} \int_{(f_i)} \int_{(f_k)} \frac{\sigma_i \sigma_k' df_i df_k}{r_{ik}} \right), \tag{8}$$

where the subscripts i, k refer to the i-th, resp., k-th conductor, and the summation extends over all the conductors of the system.

Consider the two following electricity distributions:

1) The system is placed in a given field of force with potential φ_e, the potentials (constant!) of the conductors being V_i, their charges $-e_i$, and the surface density on the i-th conductor $-\sigma_i$.

2) No external field is present. The (arbitrarily chosen) first conductor has unit charge, the other conductors are uncharged, the corresponding surface density being σ_i'.

Noting that in the case (1) the condition holds:

$$\varphi_k + (\varphi_e)_k = V_k,$$

where $(\varphi_e)_k$ is the value of φ_e in a point of the surface of the k-th conductor, and that in the case (2) φ_i' is constant on the i-th conductor and is equal to the coefficient of potential $p_{i1} = p_{1i}$ of the first conductor ([1]), equation (8) gives:

$$\sum_{i=1}^{i=n} \varphi_i' \int_{(f_i)} \sigma_i df_i = \sum_{i=1}^{i=n} e_i p_{1i} = \sum_{k=1}^{k=n} \int_{(f_k)} \sigma_k' [V_k - (\varphi_e)_k] df_k = V_1 - \sum_{k=1}^{k=n} \int_{(f_k)} \sigma_k' (\varphi_e)_k df_k,$$

i. e.

$$V_1 = \sum_{i=1}^{i=n} p_{1i} e_i + \sum_{k=1}^{k=n} \int_{(f_k)} \sigma_k' (\varphi_e)_k df_k, \tag{9}$$

which proves the proposition stated. It may be easily seen that for $n = 1$ eq. (9) coincides with (2).

In the case when the potentials V_k of the conductors are given instead of their charges e_k, it suffices to choose for σ' that density σ'' which corresponds to the case when $\varphi_i' = 1$ and $\varphi_i' = 0$ for $i > 1$, the external field being absent. Eq. (8) gives in this case:

$$\sum_{(i)} \int_{(f_i)} \sigma_i \varphi_i' df_i = \int_{(f_1)} \sigma_1 df_1 = e_1 = \sum_{(k)} \int_{(f_k)} \sigma_k'' [V_k - (\varphi_e)_k] df_k,$$

i. e.

$$e_1 = \sum_{(k)} V_k q_{1k} - \sum_{(k)} \int_{(f_k)} \sigma_k'' (\varphi_e)_k df_k, \tag{10}$$

e_1 being the charge of the first conductor in the presence of the given field of force and q_{1k} — the coefficients of induction of the first conductor.

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Received
14. IX. 1942.

REFERENCES

[1] Jeans, The mathematical theory of electricity and magnetism, 91, Cambridge (1923).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1943. Volume XXXVIII, № 7

TECHNICAL PHYSICS

CHARCOAL ELECTRODES FOR QUALITATIVE AND QUANTITATIVE SPECTRAL ANALYSIS

By V. K. PROKOFIEV

(Communicated by S. I. Wawilow, Member of the Academy, 20. X. 1942)

The preparation of sufficiently pure carbon electrodes for spectral analysis is a very difficult task, which explains the fact that various recipes for obtaining them have been published from time to time in the literature. Electrodes obtained by annealing ordinary carbons for electric arcs at high temperatures (above 2500° C) are the purest. A simple method of annealing in air by an electric current of high density has been described by Russanov (1). Owens(2) has used a similar annealing in vacuo.

Methods of chemical purification of carbon electrodes are described in the American literature(3). All these methods require, however, either strong currents or are very complicated (chemical methods) and of long duration. It is therefore natural that many suggestions were made of specific substitutes for pure carbon electrodes. Ermin and Dmitriev have proposed a method of preparing carbon electrodes from sugar and starch (4). These electrodes are sufficiently pure, but fragile and difficult to prepare and use in large quantities. The burning of powders in an arc with copper electrodes gives satisfactory results for qualitative analysis, but does not ensure a sufficient stability of the conditions which determine the burning down of the powder in the cavity of the metallic electrode, and does not yield, therefore, sufficient accuracy.

In our work such carbon electrodes had to be prepared which should not contain heavy metals, should be sufficiently strong and could be obtained from easily accessible materials. We have chosen charcoal. The first experiments have shown that charcoal obtained by burning wood in air is very fragile and does not conduct an electric current even for a condensed electric spark. The commercial coal, obtained with the help of dry distillation of wood, possesses a sufficient strength, but has no conductivity, either.

This notwithstanding, it was decided to continue the experiments on obtaining coal by way of wood distillation, mainly on the ground that the object subjected to calcining could be prepared in the form of a cylindrical stick beforehand. Such sticks 15 mm in diameter and 100—150 mm in length are made on turning-lathe.

In the sequel we preferred to saw a large rod of charcoal on saw-frame into small rods of octahedral cross-section, 500 mm long. The latter were thereafter cut into still smaller sticks, 150 mm long.

We have used the following kinds of wood: pine, oak, birch, linden and juniper.

The cut samples were placed into a tubular furnace heated by an electric current. If wood is distilled at above 350° C, a sufficiently dense coal is obtained. The initial temperature of the furnace was kept between 350—500° C. The coal sticks

obtained were sufficiently dense and withstood careful boring, but would not conduct an electric current. Though a condensed electric spark did burn in a few cases, one could see that the conductivity was not ensured by the whole mass of the electrode, but only by certain portions of extremely irregular shape. No low voltage current (110—220 volts) could be transmitted at all.

An experiment of calcining wood rods at higher temperatures (about 800° C) was performed somewhat accidentally. This experiment proved successful, the carbon electrodes obtained were excellent conductors and allowed to ignite an arc from a direct or alternating 110 volt current. At lower temperatures some resinous substances apparently remained in the coal, which deprived it of conductivity.

Further on, the process of calcining was carried out at temperatures about 800° and higher. Certain precautions were necessary. The furnace with the wood samples must be heated up from a low temperature, for a sample placed directly into the zone of high temperature will disintegrate, owing to an intense evolution of water vapour and volatile fractions. The glowing coal must not be extracted from the furnace into the air, for it begins to burn intensely. The duration of the exposure at high temperature amounts to about 2 hours. It must be noted that a marked (nearly twofold) contraction of the diameter and of the length takes place. Sometimes the coal sticks obtained are bent.

From the different sorts of wood tested linden and birch possess the highest density, oak gives electrodes with longitudinal slits, pine coal is not sufficiently dense. Juniper gives a pretty dense coal; it was not used, however, in later experiments, because of the difficulty of preparing samples of required shape (the wood is very twisted) and because the arc formed between carbon electrodes prepared from this wood gives a very intense band-spectrum (Cn bands).

Wood on burning gives about 0.5% ash. The composition of the latter is very diverse; in the ash of certain plants rare earths have been detected in minute quantities ([5]). We are interested, however, in the absolute content of these impurities, and namely of those impurities which could be observed in the spectrum of the arc burning between the corresponding carbon electrodes. These spectra were investigated in the ultra-violet region (spectrograph 13×18 GOI) and in the visible region (a large Hilger spectrograph with a glass optics, violet part of the spectrum).

It has been established that the spectrum of the arc between carbon electrodes made of various sorts of wood gives intense lines of Mg and Ca. Among other elements Na and K are found; we have also detected Sr and Ba and minute traces of Al, Cu, Fe and Cr. The latter elements display a few lines only of comparatively low intensity. The remaining part of the spectrum, especially its ultra-violet end, is very clear.

The presence of insignificant quantities of Cu, Fe and Cr should, seemingly, limit the possibilities of the application of such electrodes for qualitative and quantitative spectral analysis. Our apprehension proved, however, groundless. A qualitative spectral analysis of Fe and Cr in pure quartz sands (thousandth fractions of %) and in clays (hundredth fractions of %) was carried out with birch electrodes.

This can be explained, apparently, as follows. Ordinary carbons present mechanic mixture of various components; from the point of view of spectral analysis this mixture is strongly unhomogeneous with respect to its composition.

When these electrodes are purified by the passage of a current or in some other way, the granular character of the structure is preserved. Since different grains are cleaned from impurities to a different extent, a purified carbon electrode displays no uniform distribution of impurities, and the results of a quantitative analysis carried out with such electrodes will be greatly affected by this circumstance.

In charcoal electrodes the impurities are distributed uniformly along the fibers of the wood; one can therefore expect that coal electrodes prepared from a single

long stick (pricked out along the fibers) will contain the same amount of impurities and this will not influence the accuracy of the analysis*.

Some peculiarities of the burning of an arc with such electrodes must be noted.

A very bright glowing crater is here formed, just as in an arc with ordinary carbon electrodes. Both electrodes are strongly heated, and after the arc has been put out, the ends of the electrodes remain incandescent, glowing and burning at the expense of the oxygen of the air, so that they eventually become covered with a layer of ash.

During the burning of the arc the ends of the electrodes are sharpened as the result of a rapid combining with the oxygen of air. The temperature of the electrode along the crater is therefore not so high, as in ordinary carbon electrodes.

This temperature is, however, quite sufficient for bringing about the evaporation of quartz, introduced in the form of a fine powder in the canal of such an electrode; a complete burning out of quartz does not take place, for the burning of the walls of the electrode goes on faster than the evaporation of quartz.

Conclusions

1. A method of obtaining carbon electrodes from wood sticks is worked out.
2. Such electrodes contain considerable amounts of Mg, Ca, Sr, Na, Ba and K and insignificant traces of Al, Cu, Fe and Cr.
3. The distribution of impurities along the electrode is uniform.

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Received
20. X. 1942.

REFERENCES

[1] А. Русанов и В. М. Кострикин, Зав. лабор., 9, 1040 (1940). [2] J. S. Owens, Metals and Alloys, 9, 15 (1938). [3] A. Stand and A. Ruehle, Ind. Eng. Chem., Anal. Ed., 10, 59 (1938). [4] В. Н. Ермин и Б. Г. Дмитриев, Зав. лабор., 9, 115 (1940). [5] Journ. of the Frankl. Inst., 226, 659 (1938).

* In the investigations of these coals and of their application to quantitative spectral analysis Chramova E. F. and Prokofieva V. V. took part.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1943. Volume XXXVIII, № 7

CHEMISTRY

NEW METHOD OF PREPARATION OF MONOHYDROXO-DERIVATIVES OF TETRAVALENT PLATINUM

By A. A. GRÜNBERG and J. L. MIKHELIS

(Communicated by V. G. Chlopin, Member of the Academy, 12. X. 1942)

It has been known for a long time, that the action of chlorine on compounds of bivalent platinum leads to the addition of two chlorine atoms, along a new formed octahedron coordinate. As shown by L. A. Chugaev and V. G. Chlopin, a similar reaction takes place when compounds of bivalent platinum are acted upon by hydrogen peroxide([1]). In this latter case two hydroxy-groups instead of two chlorine atoms are added. A. A. Grünberg and B. V. Ptitzyn have shown that potassium permanganate in a sulphuric acid medium has upon compounds of bivalent platinum an action similar with that of hydrogen peroxide (a parallel case is the well known Wagner method for the preparation of glycols)([2]). In all the cases mentioned above (as well as when chlorine is substituted by bromine, iodine or nitric acid) the process proceeds in such a way that the molecule of the oxidant is cleaved into two parts, each of which is fixed in the reaction product at the ends of the newly formed coordinate. Some ideas concerning the mechanism of this kind of transformation have been formulated in the paper by A. A. Grünberg and B. V. Ptitzyn([3]). In the present paper the action of hypochloric acid on certain complexes of bivalent platinum has been studied. By analogy with transformations mentioned above one could have expected that the cleavage of the molecule of hypochloric acid would take place with the formation of the radicals Cl and OH and the fixation of these radicals in the new compound of tetravalent platinum, forming an octahedron. As in the case of molecules of halogens, hydrogen peroxide or nitric acid, one could suppose, first, the addition of a molecule of hypochloric acid, thanks to polarization forces, with the subsequent passage to this molecule of two electrons from the initial ion of bivalent platinum. The ions of Cl^- and OH^- obtained as a result of such a process are fixed in the field of the formed ion Pt^{IV}.

In case this reaction actually proceeded in such a manner, we would have a general method for the preparation of compounds containing a hydroxy group and chlorine in the transposition towards each other. The experiment showed that this was actually the case. The writers have investigated the action of an aqueous hypochloric acid solution (freshly prepared, giving no opalescence immediately after the addition of $AgNO_3$) upon $K_2[PtCl_4]$

cis- a. trans-$[Pt(NH_3)_2Cl_2]$, $[Pt(NH_3)_4]Cl_2$ and $[Pt(NH_3)_4]SO_4$.

The titre of the hypochloric acid solution was determined iodometrically.

The addition of a calculated amount (according to reaction $K_2PtCl_4 + HClO \rightarrow K_2PtCl_5OH$) of the solution of HClO to a weight portion of a platinite leads to a change in colour from pinkish-red to orange. The consecutive addition of silver nitrate to this solution leads to the formation of a considerable amount of a finely crystalline yellowish precipitate. This precipitate was filtered off with suction, washed with water and dried first in a dessicator over sulphuric acid and then in a drying oven at 90—100°.

Calculated for $Ag_2[PtCl_3OH]$: Ag + Pt — 67.90% Cl — 29.29% Found: Ag + Pt — 67.96% Cl — 29.35%

Analytical data leave no doubt about the composition of the salt.

Similarly, the action of a theoretical amount of a solution of hypochloric acid on isomeric compounds of the composition $[Pt(NH_3)_2Cl_2]$ leads to the formation of light-yellow crystalline powders having the composition $[Pt(NH_3)_2Cl_3OH]$. Below are given results of the analysis of the products obtained by the action of HClO on Peyroné's chloride and on the chloride of Reiset's second base. These products were obtained by carefully triturating the weighed out amounts of the corresponding salts in a HClO solution.

a) Product of the action of HClO on Peyroné's chloride:

Calculated for $Pt(NH_3)_2Cl_3OH$: Pt — 55.35% Cl — 30.16% Found: Pt — 55.12% Cl — 30.27%

b) Product of the action of HClO on the chloride of Reiset's second base:

Calculated for $Pt(NH_3)_2Cl_3OH$: Pt — 55.35% Cl — 30.16% Found: Pt — 55.56% Cl — 30.30%

The salt $Pt(NH_3)_2Cl_2OH$, obtained by the action of HClO on trans-$Pt(NH_3)_2Cl_2$], was reduced with a theoretical amount of potassium oxalate. It could be expected that the reaction would proceed either according to the scheme:

$$\left[\begin{matrix} & Cl & \\ NH_3 & & Cl \\ & Pt & \\ Cl & & NH_3 \\ & OH & \end{matrix}\right] + K_2C_2O_4 \rightarrow CO_2 + KHCO_3 + KCl + \left[\begin{matrix} NH_3 & & Cl \\ & Pt & \\ Cl & & NH_3 \end{matrix}\right]$$

or according to the scheme:

$$\left[\begin{matrix} & Cl & \\ NH_3 & & Cl \\ & Pt & \\ Cl & & NH_3 \\ & OH & \end{matrix}\right] + K_2C_2O_4 \rightarrow 2CO_2 + 2KCl + \left[\begin{matrix} NH_3 & & Cl \\ & Pt & \\ OH & & NH_3 \end{matrix}\right]$$

Analysis showed that the reaction product was the chloride of Reiset's second base (first scheme). However, we cannot yet consider this fact as direct proof that it is just the coordinate OH—Cl that gets off during the reduction. It is possible that reduction proceeds according to both schemes, but the chloride of Reiset's second base separates owing to its poorer solubility. Further experiments in this direction, as well as similar experiments with the products of the oxidation of the cis-isomer will be staged as soon as possible.

The action of HClO on the chloride of Reiset's first base yielded a mixture of the salts $[Pt(NH_3)_4OHCl]Cl_2$ and $[Pt(NH_3)_4Cl_2]Cl_2$. The second component of this mixture is, no doubt, a secondary product, that precipitates easily owing to its poor solubility. The action of HClO on the sulphate of Reiset's first base yielded as the main reaction product a salt $[Pt(NH_3)_4OHCl]SO_4$.

No data on the analysis of this salt or of certain derivatives of the monohydroxo-pentachloro-series (with the exception of the silver salt mentioned above) are just now at the disposal of the senior author. The corresponding materials have remained with J. L. Mikhelis, who is at present with the Red Army. It is to be hoped, however, that some time later these data, as well as data on the physical-chemical nature of the salts briefly described in the above paper, will be published.

The experimental part of this work has been carried out in the chemical laboratories of the Pavlov 1st Medical Institute of Leningrad and of the Chemical Pharmaceutical Institute of Leningrad.

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Received
12. X. 1942.

REFERENCES

[1] А. А. Чугаев и В. Г. Хлопин, Изв. Ин-та по изуч. платины и др. благ. мет., вып. 5, 85 (1927). [2] А. А. Гринберг и Б. В. Птицын, там же, вып. 11, 77 (1933). [3] А. А. Гринберг и Б. В. Птицын, loc. cit.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1943. Volume XXXVIII, № 7

CHEMISTRY

THE POLYTHERM OF THE TERNARY SYSTEM: SODIUM CHLORIDE—SODIUM BROMIDE—WATER FROM COMPLETE FREEZING POINT TO 50°

By N. A. VLASSOV and A. G. BERGMANN

(Communicated by V. G. Chlopin, Member of the Academy, 27. XI. 1942)

We give here some data on the ternary system NaBr—NaCl—H_2O([1]) which is a constituent part of a reciprocal aqueous system made up by chlorates and bromates of sodium and potassium: Na, K// Cl, Br.

In this investigation the polythermal visual method was used.

The solubility of NaCl and NaBr has been studied by numerous authors, and there is satisfactory agreement between the results obtained([2]). Concordant data have also been obtained on their verification.

For NaBr the cryohydrate point as obtained by us is —28.2° C with 40.3% NaBr. The point of transition of $NaBr.5H_2O$ into $NaBr.2H_2O$ lies at —23.8° with 41.2% NaBr. Transition from $NaBr.2H_2O$ into NaBr is at +50.2° with 53.4% NaBr.

NaCl has its cryohydrate point lying at —21.3° and 23.5% NaCl; at +0.15° and 26.3% NaCl there is a transition from bihydrate into anhydrous salt.

Schlesinger and Sorkin ([3]) have studied the composition of mixed crystals of sodium chloride and sodium bromide, separating out of water solutions at —17° to —20°, at +35° and +70°, and found that below +0.15° the chloride and bromide of sodium crystallize isomorphously with two molecules of water in the monoclinic system. At —18.5° solid solutions have been obtained with the content of NaBr. $2H_2O$ ranging from 0.53 to 91.39 mol. %.

Above +0.15° the formation of mixed crystals continues, though with a limited content of sodium bromide; at +35° the above authors have found 14.5 mol. %.

All that accords well with the data we have obtained.

The isothermal point compositions referred to in Table 1 have been obtained by graphical interpolation for —20°, —10°, 0°, +10°, +20°, +25° and +30°; the data for +50° have been cited from a work by F. I. Vassenin.

Table 1

Composition of Isothermal Points of the System NaBr — NaCl — H_2O

Weight %			Solid phase	Weight %			Solid phase
NaBr	NaCl	H_2O		NaBr	NaCl	H_2O	
Isotherm —20°							
32.8	—	67.2	Ice	17.1	13.8	69.1	Na (Cl, Br) . $2H_2O$
32.1	0.8	67.1	»	27.2	9.0	63.8	»
29.2	2.6	68.2	»	30.8	7.0	62.2	»
17.8	10.2	72.0	»	33.7	5.3	60.0	»
8.3	16.8	74.9	»	36.8	3.4	59.8	»
—	22.3	77.7	»	40.5	0.9	58.6	»
—	23.7	76.3	NaCl . $2H_2O$	41.7	—	58.3	NaBr . $2H_2O$
8.0	19.1	72.9	Na (Cl, Br). $2H_2O$				

Table 1 (continued)

Weight %			Solid phase	Weight %			Solid phase
NaBr	NaCl	H_2O		NaBr	NaCl	H_2O	
			Isotherm −10°				
21.6	—	78.4	Ice	26.9	9.8	63.3	Na (Cl, Br) . $2H_2O$
19.6	1.6	78.8	»	30.4	8.3	61.3	»
9.2	7.8	83.0	»	33.2	6.4	60.4	»
—	13.4	86.6	»	36.2	4.6	59.2	»
—	24.8	75.2	NaCl . $2H_2O$	41.4	1.2	57.4	»
7.9	20.3	71.8	Na (Cl,Br) . $2H_2O$	42.0	0.9	57.1	»
16.8	15.1	68.1	»	43.2	—	56.8	NaBr . $2H_2O$
			Isotherm 0°				
44.3	—	55.7	NaBr . $2H_2O$	30.0	9.3	60.7	Na (Cl, Br) . $2H_2O$
43.7	0.9	55.4	Na (Cl, Br . $2H_2O$	26.6	11.0	62.4	»
40.8	2.8	56.4	»	21.4	14.0	64.6	Na (Cl, Br) . $2H_2O$ +
35.8	5.7	58.5	»				+ Na (Cl, Br)
32.8	7.5	59.7	»	—	26.2	73.8	Na Cl . $2H_2O$
			Isotherm +10°				
45.9	—	54.10	NaBr . $2H_2O$	29.7	10.0	60.30	Na (Cl, Br)
44.6	1.0	54.40	Na (Cl, Br) . $2H_2O$	26.5	11.45	62.05	»
39.9	4.8	55.30	»	16.6	16.8	66.6	»
37.2	6.2	56.60	Na (Cl, Br) . $2H_2O$ +	7.8	21.6	70.6	»
			+ Na (Cl, Br)				
35.3	7.1	57.60	Na (Cl, Br)	—	26.33	70.67	NaCl
32.6	8.6	58.80	»				
			Isotherm +20°				
47.6	—	52.4	NaBr . $2H_2O$	32.55	8.65	58.8	Na (Cl, Br)
46.8	0.8	52.4	Na(Cl, Br) . $2H_2O$	29.7	10.1	60.2	»
46.6	1.0	52.4	»	26.5	11.5	63.0	»
43.8	2.8	53.4	»	16.5	16.9	66.6	»
42.4	4.3	53.3	Na (Cl,Br) . $2H_2O$ +	7.8	21.9	70.3	»
			+ Na (Cl, Br)				
39.8	5.2	55.0	Na (Cl, Br)	—	26.37	73.63	NaCl
35.2	7.3	57.5	—				
			Isotherm +25°				
48.6	—	51.4	NaBr.$2H_2O$	32.5	8.65	58.85	Na(Cl, Br)
47.6	1.0	51.4	Na (Cl,Br).$2H_2O$	29.7	10.10	60.2	»
46.3	1.8	51.9	»	26.5	11.5	61.9	»
44.6	3.4	52.0	Na (Cl,Br).$2H_2O$ +	16.6	17.0	66.4	»
			+ Na(Cl, Br)				
43.2	4.1	52.7	Na (Cl, Br)	7.8	21.9	70.3	»
39.8	5.2	55.0	»	—	26.48	73.52	NaCl
35.2	7.35	57.45	»				

Table 1 (continued)

Weight %			Solid phase	Weight %			Solid phase
NaBr	NaCl	H_2O		NaBr	NaCl	H_2O	
			Isotherm +30°				
49.4	—	50.6	$NaBr.2H_2O$	32.5	8.65	58.85	Na (Cl, Br)
48.2	1.0	50.8	Na (Cl, Br). $2H_2O$	29.7	10.2	60.1	»
45.6	3.2	51.2	Na (Cl, Br). $2H_2O$ + + Na (Cl, Br)	26.50	11.6	61.9	»
43.1	4.1	52.2	Na (Cl, Br)	16.6	17.0	66.4	»
39.8	5.2	55.0	»	7.7	22.0	70.3	»
35.2	7.40	57.4	»	—	26.52	73.48	NaCl
			Isotherm +50°				
1.75	51.62	46.63	Na (Cl, Br)	6.84	36.80	56.36	Na (Cl, Br)
2.06	49.77	48.17	»	19.15	13.21	67.64	»
3.2	46.38	49.58	»	19.26	13.30	67.44	»
6.14	38.33	55.53	»	26.93	—	73.07	NaCl

Temperature and composition at the intersection points of the curves in the section of the system are given in Table 2.

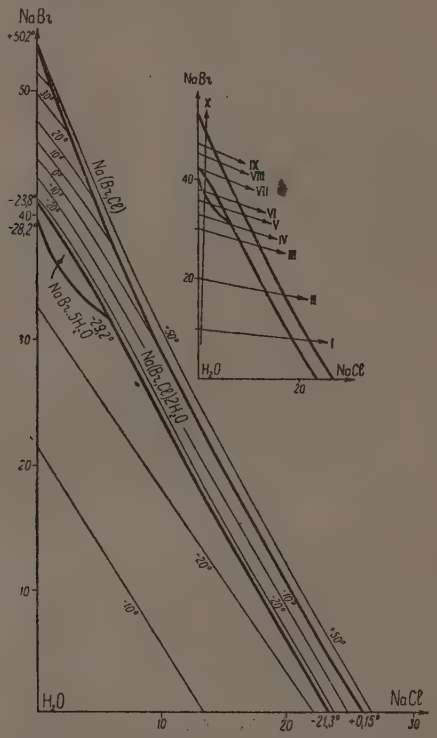
Table 2

Intersection Points on the Cross-Sections of the System

NaBr — NaCl — H_2O

t°C	Weight %		Solid phase
	NaBr	NaCl	
— 23.8	41.2	—	$NaBr.5H_2O$ + $NaBr.2H_2O$
— 28.2	40.3	—	$NaBr.5H_2O$ + ice
— 23.2	40.0	1.1	$NaBr.5H_2O$ + Na (Cl, Br). $2H_2O$
— 23.5	37.0	2.6	»
— 24.0	33.9	4.9	»
— 27.2	37.7	0.7	$NaBr.5H_2O$ + ice
— 27.0	37.2	0.9	»
— 28.0	34.6	2.7	»
— 29.0	31.1	6.2	Na (Cl, Br). $2H_2O$ + ice
— 28.8	27.4	8.2	»
— 27.6	17.2	13.2	»
— 27.6	17.2	13.2	»
— 22.5	8.0	18.8	»
— 21.3	—	23.5	$NaCl.2H_2O$ + ice
+ 50.2	53.4	—	$NaBr.2H_2O$ + NaBr
+ 32.5	45.6	3.2	Na (Cl, Br). $2H_2O$ + Na (Cl, Br)
+ 13.4	39.8	5.0	»
+ 8.0	35.2	7.0	»
+ 6.0	32.6	8.5	»
+ 4.0	30.0	10.0	»
+ 2.0	26.4	11.4	»
— 2.0	16.3	16.7	»
— 3.0	7.9	21.3	»
+ 0.15	—	26.3	$NaCl . 2H_2O$ + NaCl
+ 22.0	43.2	4.1	NaCl (Cl, Br). $2H_2O$ + Na (Cl, Br)

Chlorides and bromides of sodium in the absence of solvent, in salt melts, form most perfect solid solutions. But when these salts are in equilibrium with water, there is a rupture in the continuous series of solid solutions, owing to hydration of sodium bromide below +50.2°.



Within the temperature range investigated the system NaBr—NaCl—H_2O (see figure) has two fields of solid solutions: one is made up by solid solutions of bihydrate salts of the bromide and chloride of sodium; the other, by solid solutions of anhydrous salts*.

Besides the field of ice we have also a small field of $NaBr.5H_2O$. The fields of crystallization of ice Na (Cl, Br). $2H_2O$ and Na (Cl, Br). $5H_2O$ meet in the triple eutectic point —29.2° with 31.6% NaBr, 6.0% NaCl, 62.4% H_2O.

Received
27. XI. 1942.

REFERENCES

[1] A. G. Bergmann and N. A. Vlassov, C. R. Acad. Sci. URSS, XXXV, No. 9 (1942); XXXVI, No. 2 (1942). [2] Landolt-Börnstein, Physik.-Chem. Tabellen (1923—1935). [3] Шлезингер и Зоркин, Тр. Центр. н.-и. станции геохимии солей ГГУ, вып. 1, 119 (1936).

* Above 0° C the isotherms in the field Na (Cl, Br) are so close to each other that we thought it sufficient to give only the extreme isotherm of +50°.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1943. Volume XXXVIII, № 7

EXPERIMENTAL BIOLOGY

THE INFLUENCE OF PHYTONCIDES UPON PROTOZOA

By B. TOKIN

(Communicated by L. A. Orbeli, Member of the Academy, 12. XI. 1942)

In the course of our experimental morphological studies carried on during 1928—1930, we succeeded ([1],[2]) in discovering quite a peculiar phenomenon: if a small amount of paste is prepared of onion or garlic, *Raphanus sativus*, *Cochlearia armoracica* or some other plant, this paste emits within the very first 5—10 minutes volatile substances which produce a lethal effect upon yeast cultures of the races *Chabli*, *Nadsonia* etc., when for 1—5 minutes placed at a distance of several centimeters. An identical effect has been obtained with eggs of molluscs and frogs.

This collateral observation, though originally out of the scope of our scientific work, has stimulated a numerous staff of biologists, microbiologists and medical men to extensive and manysided studies, resulting finally in the discovery of the phytoncides (this was the name coined by me for the volatile substances produced by plants in the course of their life-activity, and endowed with strongly bactericidal and protistocidal properties).

The chemical nature of the phytoncides still remains obscure; the only thing that is obvious is that they are not identical with the essential oils of plants, i. e. with that, occasionally rather complicated mixture of organic compounds, which is obtained by a chemist or a pharmacologist upon distillation of oils with water vapour, or upon extraction and maceration. This is brought forth by the fact (supported by numerous experiments), that the phytoncides volatilize within a short period of time upon the preparation of the vegetable paste; under the usual conditions of production of essential oils the phytoncides do therefore escape the attention of the analyst.

In this paper are exposed the main data on the effect produced by phytoncides upon Protozoa, which seems to present some interest both for biology and medicine.

The plants most thoroughly studied for the influence of their phytoncide vapour are *Allium cepa* and *Allium sativum*. The phenomena described below are, however, inherent not to these plants alone, but to a number of other plants among more than 150 species studied by the author.

The originally rather complicated experimental technique was in the subsequent reduced to quite an elementary procedure. There is to be taken a drop of water or of a hay infusum, containing a culture of the Protozoa we are interested in. The drop is put on an object-glass; meanwhile there is quickly prepared a small amount of paste of onion, garlic or some other plant to be tested. When ready, the paste is put at the bottom of a Petri dish. At a distance of several millimeters or centimeters from the paste is to be placed on a holder the object-glass with a suspended drop, containing the object to be investigated. After this the Petri dish must be covered to prevent the phytoncides from evapora-

ting. The experiments can also be carried out without any appliances, simply putting some paste next to the «protozon drop» on the object-glass or near it.

The results of our numerous experiments may briefly be summarized as follows: small portions of a paste, freshly prepared with onion, garlic or some other plants, emit a quantity of phytoncides sufficient to kill within 1—2—5 minutes all the monocellular organisms treated with this paste.

Until now we have never met such representatives of Protozoa, either pathogenic or not, that would prove resistant against phytoncides of onion and garlic.

The species investigated by the author most thoroughly is *Paramaecium caudatum*. In their gaseous state the phytoncides seem to penetrate through the «ectoplasmic» layers of the cells practically instantaneously.

Special experiments, made with the purpose to test the paste for the durability of its protistocidal properties, have shown, however, that not all phytoncides are spent at once, and that traces of them can be detected during a rather prolonged period of time, which may vary considerably as to the plant.

Thus, in a paste prepared with onions we failed to discover any traces of phytoncides as soon as 30 minutes after it had been left uncovered. Contrary to this, a paste made of roots of *Paeonia anomalia* preserved its strong protistocidal properties even after 24-hour long exposure to fresh air.

An exceptional volatility of the phytoncides was found to be common to all the plants investigated. The following experiment goes to confirm the high volatility of phytoncides. A glass tube 128 cm long and about 2 cm across is fixed in a vertical position. Its bottom end is united to a funnel whose wide portion serves to prevent the phytoncide vapour, emitted by the onion paste placed directly under the mouth of the funnel, from dissipating. Above the top aperture of the tube there is fixed an object-glass with a suspended drop, containing the monocellular organisms to be tested. Under such experimental conditions a 5—8-minute exposure is sufficient for all Protozoa to be killed.

Special investigations which are to be described elsewhere have made it quite evident that in all the cases of influence of phytoncides upon bacteria, fungi or Protozoa, the effect produced is of purely chemical nature, and the possibility of any hypothetical radiative factors being operative here should be entirely excluded.

A question which has remained unsolved until the end of our investigation is that of the water solubility of the phytoncides. If the phytoncide vapour emitted by onion and garlic is apt to kill organisms in a water drop, this should be taken to mean that they are, though poorly, soluble in water. L. Ferri from this laboratory diluted with water freshly prepared onion juice at a ratio 1 : 10 and found it to produce upon Protozoa a still energetic killing effect. In the course of our numerous experiments, made with the aim to clarify the question as to the water solubility of phytoncides, we run, however, across such phenomena that still defy accurate analysis. It was established, that the phytoncides of a number of plants produce their lethal effect upon bacterial cultures grown upon solid nutrient media, whereas they do not kill Protozoa contained in a water drop. Thus, the phytoncides of *Capsicum annuum* are endowed with excellent bactericidal properties, but they produce upon Protozoa included in a water drop either no effect at all, or their effect sets in only after as much as 30—35 minutes of exposure. A similar picture was revealed in the course of our experiments with the phytoncides of mustard, which are endowed with powerful bactericidal properties, but whose effect upon test-objects in a water drop proved to be nil.

On the other hand, there are phytoncides that seem to be characterized by a water solubility still higher than that of onion and garlic phytoncides. Such are the phytoncides of *Radus racemosa*. If a branch of this plant is put on a table near to a Petri dish filled with water containing various Protozoa, and the whole is covered with a glass bell, after 20 minutes all the Protozoa will be found dead.

Lastly we have to dwell upon the action of essential oils of plants as upon one of the most important factors revealed by our experiments. It has been known long since both from scientific literature and medical practice that essential oils produce a lethal effect upon fungi and bacteria. In the 19th century, for instance,

the essential oils of Coniferae used to be applied in surgical practice to the sterilization of catgut. All these data, however, stand in need for additional investigation, for in many cases the authors were undoubtedly dealing not with essential oils, but rather with phytoncides.

The present author in collaboration with A. Witheft carried out a series of experiments on the effect produced by the vapour of essential oils upon Protozoa. A drop of some vegetable oil was placed into a depression of an object-glass. The edge of this depression was smeared with vaseline and covered with a covering glass, to the lower surface of which there was attached a drop of water containing Protozoa. As a result of these experiments, the vapours of essential oils of various plants were found to require for their lethal effect upon monocellular organisms an exposure of varying length: in the case of *Ocinum gratissimum* the Protozoa perished after a 3—5-minute exposure; for *Origanum majarana*, *Thimus serpillum*, *Artemisia siversiana*, *Hyssopus officinalis* and *Dracocephalum moldavicum* the respective figures are 2 min., 1 min., 30—60 sec., 30 sec. and 2—3 sec.

If the experiments on the essential oils of the plants enumerated above are carried out under usual conditions, as described for those with onion and garlic phytoncides, the exposure required to kill Protozoa is a much longer one. Thus, in the case of *Thimus serpillum* it is 15—17 minutes, in the case of *Dracocephalum moldavicum* 6 minutes, etc. Such factors, as a considerable distance between the object and the source (1—1.5 cm), the possibility of dissipation of the vapour, etc., are not without effect upon the results of the experiments.

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Received
12. XI. 1942.

REFERENCES

[1] Б. Токин и А. Бараненкова, Тр. лабор. экспер. биол. Московского зоопарка, 5 (1931). [2] Б. Токин, Митогенетические лучи (1933). [3] А. Филатова и А. Тебякина, Микробиология, II, 3 (1933). [4] А. Филатова, Тр. Биолог. ин-та Томск. ун-та, VII (1940).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1943. Volume XXXVIII, № 7

EXPERIMENTAL BIOLOGY

MECHANISM OF ACTION OF PHYTONCIDES UPON PROTOZOA

By A. KOVALENOK

(Communicated by L. A. Orbeli, Member of the Academy, 18.XI.1942)

As a result of a several year investigation, B. Tokin and A. Filatova have succeeded in establishing that the volatile substances (phytoncides) evolved by a freshly prepared gruel from onions (*Allium cepa* L.), garlic (*Allium sativum* L.) and a number of other plants, are endowed with powerful bactericidal properties. Three—five minutes of phytoncide treatment have been found sufficient to inhibit the development of, or to kill various species of, fungi and bacteria investigated by them. It has also been found that phytoncides are able to kill monocellular both free-living and parasitic organisms (various species of infusoria, etc.). In connexion with the attempt made by medical practitioners to apply phytoncides to the treatment of a number of affections caused by Protozoa, this question assumes not only theoretical, but also practical importance.

The present author has carried out a special investigation with the purpose to disclose the mechanism of action of phytoncides upon several species of free-living infusoria, upon some flagellates and upon *Opalina ranarum* Ehrbg. infusoria, parasitic of the intestine of the frog (*Rana arvalis* L.). The effect of phytoncides from one and the same plant applied for an identical period of time has been found to vary as to the species of the infusoria treated. Their effect upon Protozoa is a lethal one, but the biological mechanism of their death is different, according to the species.

When acted upon with phytoncides, *Paramaecium caudatum* Ehrbg. shows from the very first moment of exposure a higher rate of movements, which becomes its double or triple. This effect is akin to that described by B. Tokin for eggs of molluscs which, previous to succombing to the lethal action of phytoncides, display a sharp intensification of their vital functions. After one minute the movements begin to slow down and by the end of the third or fourth minute cease altogether, and the infusoria perish. Important morphological changes are found to take place: the anterior end becomes rather pointed, while the posterior end rounds out; the protoplasm grows less transparent and shows a well pronounced granular structure; the macronucleus is clearly to be seen.

Several minutes (3—10) after the movements have ceased, the surface of the body appears to be covered with numerous transparent vesicles. The details of their formation are as follows:

1) The vesicles form 3—5—10 minutes after the infusoria ceased moving or, in some cases, their appearance coincides with the total extinction of motion.

2) As a rule, there takes place a simultaneous formation of numerous vesicles.

3) The vesicles are regular geometrical bodies, viz. ideal spheres connected with the body of the infusoria at a single point.

4) The contents of the vesicles are absolutely homogeneous.

Up to the present we dispose of no significant data as to the nature of these formations. If we were to assume that their contents are due to an intense evacuation of vacuoles, we would be at a loss to account for the large volume of the vesicles formed. There are cases when the total volume of the numerous vesicles exceeds that of the body of the infusoria.

No less enigmatic is the ideal homogeneity of the contents of the vesicles. Should we suppose that there takes place protrusion of a region of the pellicle at a given point of the body, and squeezing out of the contents of the contracting vacuole, why then corresponding parts of the protoplasm, which are in a liquid aggregate condition, do never get into the vesicles formed? If they did, the contents of the latter would never show such a homogeneous structure. We feel therefore embarrassed to suggest any adequate interpretation. There may possibly take place an energetic reaction between the phytoncide vapour and the superficial layers, the contents of the vesicles being a product of that reaction. It is also tempting to suggest that the semipenetrability of the pellicle may be liable to change phytoncides. If we were to adopt this view, the formation of vesicles might be referred to phenomena of plasmolytic nature. The infusoria may remain in their fixed condition until the drop of the liquid gets dry; in some cases, however, the pellicle was seen to be destroyed soon after the movements had ceased, and the plasm flew out. From a number of tests it has been established that a 30-sec. treatment is sufficient to bring about irreversible changes in the plasm of *Paramaecium caudatum*, and a lethal effect set in three—four minutes after the exposure to phytoncides had been stopped.

It is of interest to note that as soon as after $^1/_2$ a minute of treatment the protoplasm and the macronucleus of *Paramaecium caudatum* become liable to a diffuse staining with Neutralrot, taken at a concentration which for itself is no lethal one, but only calls forth the reversible phenomenon of granulation. In none of the cases could we observe phenomena of paranecrosis ([1]). This points to the fact that phytoncides penetrate into the cell with an exceptional velocity and cause Protozoa display irreversible changes. Below there are given records of an experiment involving phytoncide treatment of *Paramaecium caudatum*.

As soon as the treatment is started, the infusoria begin to move much more swiftly. After 40—60 sec. the movements become slower, the protoplasm becomes less transparent, the anterior end grows pointed, the posterior rounds out. After $1^1/_2$—2 min. onward motion ceases almost altogether, the movements of cilia are well perceptible, the macronucleus clearly seen; individual infusoria are already dead. After three minutes all infusoria have perished. From three to seven minutes after a total standstill transparent vesicles begin to appear all over the body of the infusoria; they are often rather numerous. Occasionally the vesicles make their appearance as soon as movements have stopped.

In the case of a 3-minute long treatment of *Stentor coeruleus* Ehrbg. with phytoncides, the body of the infusoria contracts sharply, onward movements slow down. The protoplasm grows less transparent, its viscosity increases; the macronucleus is well perceptible, though somewhat displaced with respect to its original position. Ultimately, the body of the infusoria undergoes disintegration.

It should be noted that all the structures, as well as the shape of the body, are preserved within a certain time only in case phytoncides are applied at a high dose. Treatment of *Spyrostonium teres* Clap. Lash. with small doses of phytoncides (instead of a Petri dish, onion gruel was placed on an object-glass, near a drop of water containing the infusoria) calls forth at once contraction of the body along the longitudinal axis, onward motion gives place to rotary one; after 10—20 sec. the former sets in again, this time accompanied by convulsive contractions. The contractory vacuole stops functioning and increases in size. After 8 min. the infusoria ceases to move; after 5—7 min., sometimes directly after they have stopped moving, granular disintegration sets in. Under usual experimental conditions, when the object-glass is placed into a Petri dish containing onion gruel, granular disintegration sets in after 2—3 min., being preceded by a sharp contraction of the body.

The effect of phytoncides upon *Stylonychia mytilus* Ehrbg. is sharply to accelerate the movements; lysis sets in within the very first seconds of treatment. Within two, occasionally even within one minute, the whole body undergoes lysis which begins at the peristomatic region; in the course of lysis the body gradually diminishes in size, though the mobility is preserved almost till the end of lysis.

Some small forms of infusoria of the genus *Stylonychia* have been found more resistant to phytoncides; the infusoria perished after a 4—5-minute treatment. In this case we observed neither lysis nor granular disintegration, but rather «fixation» of the cell.

When acted upon with phytoncides, *Loxodes rostrum* O. F. Müll. shows lytic disintegration; the process starts at the anterior end of the infusoria within the first second of treatment, and takes no more than 10—15 seconds.

Opalina ranarum Ehrbg. perishes after 2 min. of phytoncide treatment. There is observed coagulation of the protoplasm, the nuclei are well perceptible in the form of light homogeneous spots, the body shape scarcely changes. We failed to observe disintegration of the infusoria; on the contrary, they may remain intact during several hours, unless the drop of the liquid gets dry. In this case we may speak of a fixation of the infusoria.

A colony of *Volvox* perishes after 2 min. of phytoncide treatment; no intensified movements were observed in this case. The dead colonies may show no signs of disintegrating during 5 days.

Besides the phytoncides of *Allium cepa*, we treated those of *Allium schoenophrasum* L. and of roots of *Paeonia anomalia*. All of them were found to call forth identical changes in Protozoa and to produce a lethal effect, and it is only the exposure that should be varied according to the plant used. Thus, in the case of *Allium cepa* an exposure of 2—3 min. is sufficient to cause a lethal effect in infusoria; phytoncides of *Allium schoenophrasum* require an exposure during 3—5 min., while those of the roots of *Paeonia anomalia* produce their lethal effect after a 7—9-minute treatment.

The data secured by us from our experiment on Protozoa may be helpful in the investigation of the action of phytoncides upon the cells and tissues of polycellular animals; they may possibly suggest some details of practical application of phytoncides to the control of pathogenic Protozoa.

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Received
18.XI.1942.

REFERENCES

[1] Д. Насонов и В. Александров, Реакция живого вещества на внешние воздействия (1940).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1943. Volume XXXVIII, № 7

MICROBIOLOGY

BIOLOGICAL ACTIVITY OF ACYL DERIVATIVES OF THE VIRUS OF TOBACCO MOSAIC

By V. L. RISCHKOV and A. M. VOVK

(Communicated by L. A. Orbeli, Member of the Academy, 27. XI. 1942)

It being shown by Agatov ([1–3]) that the protein of the tobacco mosaic virus is still able, after acyl groups have been introduced into it, to produce the effect of local necroses in *Nicotiana glutinosa*, there naturally arises the question, whether its infectuous power over plants is or is not as persistent in the case of species in which *Nicotiana* virus Allard provokes general affection. It is also of interest to establish, whether the molecule of the virus is not deprived of its ability of self-reproduction by the introduction of the acyl radical; in other words, whether the virus remains capable of passage through a series of experimental plants. If it does, there is a further question to be solved, is the picture of the disease caused by the virus a typical one, and may not the symptoms that develop after the introduction of the acyl derivatives show a different character? A series of works on these questions has been planned to end with an investigation of the virus protein separated from plants infected with its acyl derivatives. This last work has been accomplished by P. A. Agatov.

Our experiments were run with tobacco and tomatoes. What we have found is seen in Table 1.

Table 1

Virus	Tobacco		Tomato	
	Inoculated	Affected	Inoculated	Affected
Typical	5	5	14	6
Benzoylized	11	5	7	1
Do	5	5	7	7
Acetylized	5	5	7	6

It is evident from this table that the benzoylized and acetylized viruses fully retain their activity against tobacco and tomato plants. The symptoms of the developing disease were found on careful observation to be identical in the plants infected with the typical virus and in those infected with its derivatives. In order to prove that the virus is or is not able of passage, the juice of the plants infected with the acyl derivatives was inoculated on other specimens of tobacco and tomato. The results of these tests are presented in Table 2.

Table 2

Passage Tests with Acyl Derivatives of Tobacco Mosaic Virus

Origin of virus	Tobacco		Tomato	
	Inoculated	Affected	Inoculated	Affected
Tobacco infected with benzoylized virus	2	2	7	5
Tobacco infected with acetylized virus	—	—	9	7
Tobacco infected with typical virus	—	—	6	5

In none of these tests did the control plants yield to infection. Their number was eleven in the experiment to which the data of Table 2 refer. It has thus been proved that the acyl derivatives of the virus preserve their infectuous power undiminished and call forth symptoms identical with those provoked by the typical virus. These facts alone furnished sufficient ground for the assumption that in the organism of the plant, into which the acyl derivatives are introduced, a building up of invariable typical molecules of the virus takes place. Later this assumption found confirmation in the work of P. A. Agatov.

To such conclusion have brought us our experiments which were first conceived by the workers of this laboratory as early as in 1937. At that time we had in mind to introduce the radicals into the virus protein in order to block its active groups. We hoped to succeed in the reactivation of the virus by removing the radicals from its molecule. The result, however, was quite unexpected; the virus molecule, though it had most of its amino-groups blocked by acyl radicals, was none the less active for that. Similar results have been obtained by Stanley and Miller (4). The latter authors, it is true, have found the activity of the virus to be reduced by 25—30% when 75 to 83% of the amino-groups were bound by acetyl. Yet, this may hardly be taken to mean that the activity of the virus depends upon the presence of free amino-groups; a certain weakening of the virus may simply be accounted for by the lengthy chemical treatment required by a preparation, in which 80% of the amino-groups are to be in a bound state.

For explaining these results, so unexpected and paradoxical, we made the assumption that in the living vegetable cell the acylated molecule of the virus undergoes saponification which makes it regenerate in its typical state.

Indeed, it may easily be supposed that there are some enzymes in plant to bring about this process, similar to the enzyme that saponifies hippuric acid in animals. Unfortunately, all attempts to prove the presence of such an enzyme in the juice of tobacco by *in vitro* tests have as yet been failures. But this negative result is, of course, no evidence that the regeneration of typical molecules of the virus is not favoured by conditions prevailing in the protoplasm of plants. The existence of such conditions still appears to provide the most probable explanation of the phenomenon.

Be that as it may, the results obtained in this and other laboratories concerning the preservation of activity by acyl derivatives of the virus are of great importance, since they point to the necessity of discriminating between those modifications of the virus molecule which are and those which are not preserved on the self-reproduction of the virus. It is the latter kind of modification that takes place in the case of acylation of the virus.

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Received
27. XI. 1942.

REFERENCES

[1] П. А. Агатов, Биохимия, 6, 269 (1941). [2] P. A. Agatov, C. R. Acad. Sci. URSS, XXXIII, No. 7 (1941). [3] P. A. Agatov, ibid., XXXVIII, No. 2—3 (1943). [4] G. Miller and W. Stanley, Science, 98, 428 (1942).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1943. Volume XXXVIII, № 7

HELMINTHOLOGY

CONTRIBUTION TO THE RECONSTRUCTION OF THE TAXONOMY OF THE TREMATODES OF THE FAMILY *LECITHODENDRIIDAE* ODHNER, 1911

By T. S. SKARBILOVICH

(Communicated by K. I. Skrjabin, Member of the Academy, 7. IX. 1942)

In spite of the fact that the first genera of the trematodes of the family *Lecithodendriidae* Odhner, 1911, were founded as far back as in 1896 by Looss, and that this family which embraces 31 independent genera has up to the present been described in a number of fundamental papers, the taxonomy of *Lecithodendriidae* can yet not be considered satisfactory.

This is mainly due to the fact that characters of unequal importance were suggested by different authors to serve as taxonomical coefficients.

As a result of monographical investigation of the *Lecithodendriidae* we found it necessary to introduce a number of essential corrections into the taxonomy of this group of trematodes, viz. to subdivide the subfamilial cathegories into tribes, and to found 4 new genera.

Our conclusions may be summed up in the following form.

1. We divide the *Lecithodendriidae* into 3 subfamilies, taking as a basis for their characteristics the situation of their sexual aperture: in the *Lecithodendriinae* Looss, 1902, it is situated medially before the abdominal sucker, in *Gyrobascinae* Macy, 1935, medially, behind the abdominal sucker, while in *Pleurogenetinae* Looss, 1899, it is situated on the lateral edge of the body.

2. Each subfamily is subdivided by us into tribes, on the basis of the following 2 characters: a) presence or absence of the sex bursa and b) arrangement of the sexual aperture with respect to the abdominal sucker.

3. Those of the *Lecithodendriinae* which have no sexual bursa (or have a pseudobursa), the sexual aperture not being situated at the anterior edge of the abdominal sucker, are referred to the tribe *Lecithodendriea* nov. tr. The genera which have a sexual bursa, and whose sexual aperture is situated at the level of the pharynx or the intestinal bifurcation, are referred to the tribe *Phaneropsolea* nov. tr.

4. The *Gyrobascinae* which lack a sexual bursa and have their sexual aperture shifted considerably to the posterior end of the abdominal sucker, are classed among *Gyrobascea* nov. tr.; the genera provided with a sexual bursa and with a sexual aperture situated near the posterior edge of the abdominal sucker, are referred to *Limatulea* nov. tr.

5. The *Pleurogenetinae* are also subdivided by us into 2 tribes: a) the *Pleurogenea* nov. tr. with a sexual aperture situated on the lateral edge of the body, anteriorly to the abdominal sucker, and b) the *Brandesiea* nov. tr., with their sexual aperture situated on the lateral edge of the body at the level of the abdominal sucker, or behind same.

6. The species *Lecithodendrium orospinosa* Bhalerao, 1926, from the intestine of the brachypterus *Nyctinomus plicatus* should be isolated as a type of a special genus *Skrjabinodendrium* n. gen., under the following diagnosis.

Diagnosis. *Lecithodendriea* of a rather small size, of an oval shape and with a smooth cuticulum. Large oral sucker armed with spines. Oesophage lacking. Intestinal trunk short, directed transversely. Sexual aperture situated medially, anteriorly to the abdominal sucker. Testes at the level of the sexual aperture, sexual bursa lacking, ovaries situated to the left at the edge of the left testis. Seminal vesicle rolled, lying anteriorly to the abdominal sucker. Vitellaria in the form of a double chain lying in the anterior part of the body; eggs large, 0.038× 0.014 mm. Parasitic of the bat.

7. The species *Lecithodendrium bhaleraoi* Pande, 1935, from the intestine of the brachypterus *Nycticejus kuhli*, is given the rank of a new genus, *Travassodendrium* n. g., under the following diagnosis.

Diagnosis. *Lecithodendriea*, oval in shape. Abdominal sucker situated in the middle of the body, it may be slightly shifted either anteriorly or posteriorly. Sexual aperture medial at the anterior edge of the abdominal sucker. Testes situated anteriorly to the abdominal sucker, symmetrically at either side of the body, occasionally slightly shifted, the one anteriorly, the other posteriorly. Ovary full-edged, lying anteriorly to the abdominal sucker, at the level of the testes, or considerably shifted to the anterior part of the body. Pseudo-bursa with a winding seminal vesicle. Vitellaria in the form of groups of follicles situated at the level of the oral sucker; the latter almost always shifted to the ventral side. The loops of the womb numerous, situated mostly in the posterior half of the body, small loops reaching the zone of the testes. Eggs 0.022—0.035 mm long and 0.012—0.017 mm wide. Parasitic of the intestine of Brachyptera.

Aside from the typical species, we refer to this genus: *T. pushpai* (Bhalerao, 1936), *T. mehrai* (Pande, 1935) and *T. allahabadi* (Pande, 1935) = *L. longiforme* var. *allahabadi* Pande, 1935.

8. We separate the species *Lecithodendrium luzonicum* Tubangui, 1928, from *Scutophilus temmincki* as a type of a new genus, *Chiroptodendrium* n. g. under the following diagnosis.

Diagnosis. Rather small *Phaneropsolea*, elongated in shape, with a smooth cuticle. Pharynx and short intestinal trunks, directed latero-caudally. Sexual glands situated anteriorly from the abdominal sucker. Sexual aperture opens directly behind the pharynx. Sexual bursa large, globular, situated medially between the pharynx and the abdominal sucker. Seminal vesicle winded. Testes globular, situated symmetrically at either side of the anterior-lateral edge of the abdominal sucker. Ovary round, lying medially between the testes. Vitellaria consisting of numerous grape-like follicles, situated in the medial part of the body, in the region of the intestine, pharynx and oral sucker, the posterior follicle reaching the anterior edge of the testes. Womb filling the space behind the abdominal sucker. Eggs 0.037 mm long and 0.016 mm wide. Parasitic of the Brachyptera.

9. The species *Lecithodendrium echinuscus* McIntosh, 1936, from the cysts of *Icteria virens*, is given the rank of a new genus, *Echinuscodendrium* n. gen., under the following diagnosis.

Diagnosis. *Gyrobascea* whose cuticle is covered with spines. Pharynx and oesophagus present, intestinal trunks broad, reaching as far as to the posterior edge of the abdominal sucker. Testes oval in shape, unequal in size, the left one considerably larger than the right one. Sexual aperture situated medially, behind the abdominal sucker. Ovary large, consisting of 3—4 lobes. Vitellaria very large, the follicles forming a kind of broad bands encircling the oesophagus. Womb forms transverse loops, filling the posterior half of the body and reaching the lateral edges of the body. Eggs 0.027 and 0.020 mm, armed at the basal pole with a short spine-like process.

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Received 7. IX. 1942.

REFERENCES

[1] Bhalerao, Journ. Burma Res. Soc., 45 (1926). [2] Tubangui, The Philippine Journal of Science, 36, No. 3, 366 (1928). [3] Odhner, Results of the Swedish Zoolog. Exped. to Egypt 1901, part. IV, No. 23 A (1911).

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